

PRACTICAL

JULY 1986 • £1.25

ELECTRONICS

SCIENCE AND TECHNOLOGY

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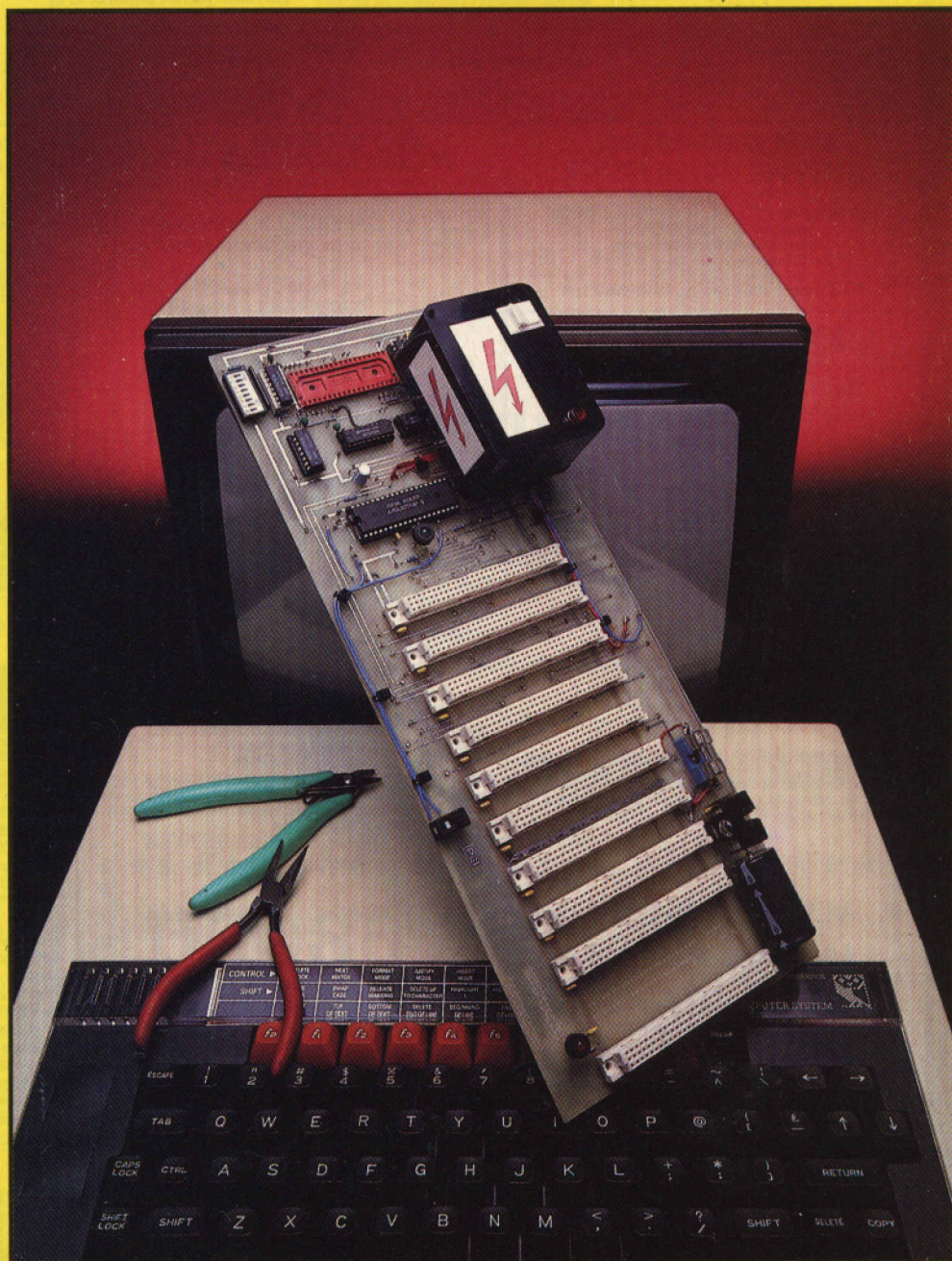
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MICROMOUSE-
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RS-232
BREAKOUT BOX

ECHO REVERB
SOUND EFFECTS

PASSIVE I.R.
DETECTOR



HOBBYBUS IN ACTION—HOW TO
CONNECT THE BUS TO YOUR COMPUTER

Editor: Richard Barron

Consultant Editor:

Nick Hampshire

Editorial Assistant:

Mary-Ann Hubers

Advertisement Manager:

Alfred Tonge

Publisher: Angelo Zgorelec

Readers' Enquiries

All editorial correspondence should be addressed to the editor and any letters requiring a reply should be accompanied by a stamped addressed envelope. Please address editorial correspondence to: **Practical Electronics, 16 Garway Rd., London W2 4NH. Tel. 01-727 7010**

We regret that lengthy technical enquiries cannot be answered over the phone.

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In order to avoid disappointments, in the future, we suggest that you take out a subscription. Not only will you avoid missing an issue but you will also save money and in most cases receive your copy before it is in the local newsagents.

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OUR AUGUST 1986 ISSUE WILL BE ON SALE FRIDAY, JULY 4th, 1986 (see page 57)

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WHAT'S NEW...

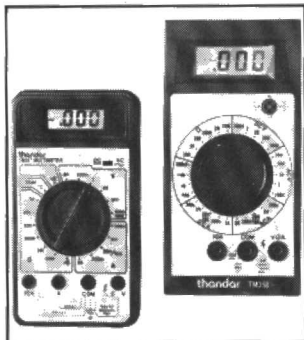
Two from Thandar

Thandar Electronics have announced the addition of two further digital multimeters to their range, designated the TM357 and TM358.

The TM357 is a 3-5 digit l.c.d. multimeter with facilities to read a.c./d.c. voltage, current, resistance and diode test. A continuity buzzer is also provided.

The TM358 is a 3-5 digit l.c.d. multimeter which, besides incorporating similar ranges to the TM357, has the additional feature of conductance and transistor *hfe* measurement.

Details from: Thandar Electronics Ltd, London Road, St. Ives, Huntingdon, Cambs PE17 4HJ.



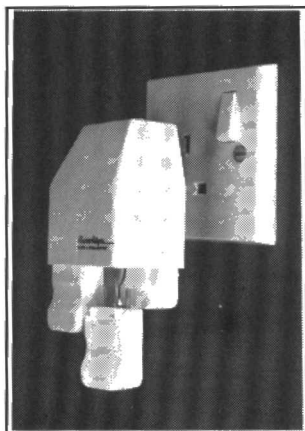
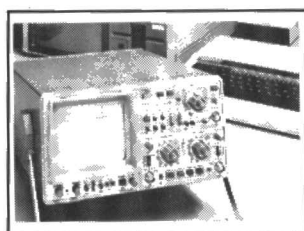
IEEE option scope

Paxton Instruments of Letchworth, Herts, announce the introduction of the HM208 digital storage oscilloscope with IEEE option.

This is a 20MHz realtime oscilloscope in addition to the 20MHz sampling frequency in the digital storage mode. The storage memory size is $4 \times 1K \times 8$ -bit; if, however, used in the single channel mode, channel 1 resolution becomes $2K \times 8$ -bit.

The HM208 IEEE also has a second page memory facility which enables captured signals to be saved for later reference, whilst freeing the original memory for separate storage of channel 1 and/or channel 2.

Details from: Paxton Instruments, Unit B1, Pixmore Industrial Estate, Pixmore Avenue, Letchworth, Herts.

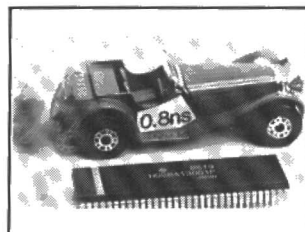


Plug it!

Latest in the line of safe, compact, mains adaptor products from Masterpiece is the Masteradapta.

Now available from leading high street and diy stores at under £10, this adaptor is designed to plug directly into a 13A mains socket and accept four miniature 6A, 3-pin plugs which are compatible with other Masterplug adaptors. This gives an extremely neat and compact arrangement for operating up to four low power appliances (less than 1500W each) from a single 13A mains socket.

Details from: Masterpiece Products, Masterpiece Cabinets Ltd, Annscroft, Shrewsbury SY5 8AN.



Fast gates with power

Hitachi have made another technology and production breakthrough with their new HG28 series of gate arrays.

The gate arrays now feature a combination of super high speed and low power dissipation. At 0.8ns/gate the new series has broken through the 1ns gate barrier and has achieved this, not only with no compromised power, but with a particularly low power dissipation—just 0.22mW (typ. at 10 MHz) for an internal gate.

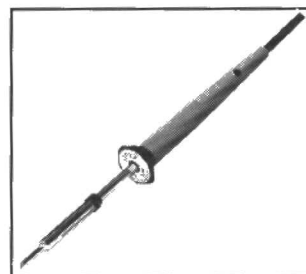
Details from: Hitachi Electronic Components (UK) Ltd, 21 Upton Road, Watford, Herts WD1 7TB.

In civvy street

The comprehensive Oryx soldering iron range has been extended by the introduction of the Oryx 15W 240V lightweight iron. This low cost iron is based on a successful unit Oryx has built for a national public service organisation, which has used a similar device for many years.

Now in 'civvy' colours of orange and black and presented in a point-of-sale transparent package, this unit will serve all aspects of the market from the hobbyist through to industrial applications. The temperature is set at 350°C nominal from a wire-wound element in a tubular ceramic insulator. The soldering tip is iron plated for long life.

Details from: Greenwood Electronics, Portman Road, Reading, Berks RG3 1NE.

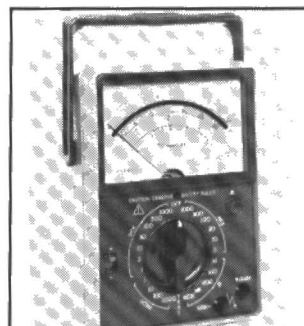
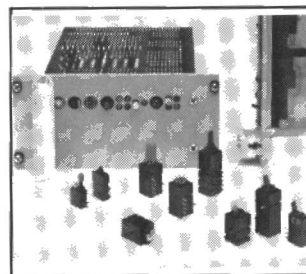


Switches

West Hyde have announced an extensive series of miniature switches for p.c. mounting. The range comprises over 80 different versions including push-button, toggle and rotary types. Very small dimensions mean that a large number of devices can be fitted into a small front panel area.

Of particular interest are a VDE-approved mains toggle switch needing only 10×10 mm of panel space, a contactless Hall effect push-button switch, and a variety of binary-coded rotary switches.

Details from: West Hyde Developments Limited, 9-10 Park Street Industrial Estate, Aylesbury, Bucks HP20 1ET.

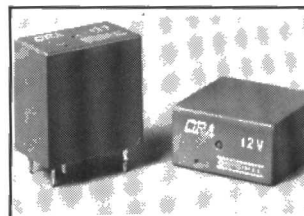


Triplet and Metex are back

Triplet analogue multimeters and Metex digital multimeters are now available from Alpha Electronics Ltd and reflect the recent growth at Alpha that has necessitated a move to larger premises at Atherton, just outside of Bolton.

Alpha have become the exclusive UK outlet for the Triplet 60 Series of analogue multimeters, said to be extremely robust and reliable. Model 60 is designed with 'user safety' in mind. High impact case, large easy to read taut-band mirror scale meter and unique fuse protection on all ranges give an instrument that is both mechanically and electrically robust.

Details from: Quiswood Ltd, 21 Eastbury Court, Lemsford Road, St Albans, Herts AL1 3PS.



Miniature power relays

Specialist component distributors, Selectronic of Witney, have introduced the ORA miniature power relay, manufactured by the Original Electric Manufacturing Company.

The ORA relay is a p.c.b. s.p.d.t. device. Three types are available: the ORA operates at 3A, the ORAM at 5A and the ORAH at 7A. The relays are available with six nominal coil voltages, ranging from 3 to 48 V d.c. Nominal currents range from 120 to 13mA for the normal version and 66 to 9mA for high sensitivity types.

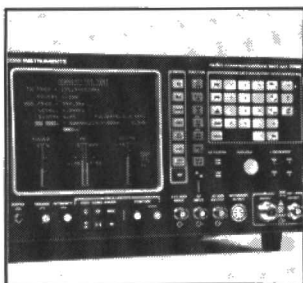
Details from: Selectronic Ltd, The Old Stables, 46 Market Square, Witney, Oxon OX8 6AL.

WHAT'S HAPPENING...

Flexible transceiver test set

Marconi Instruments' versatile 2955 Radio Communications test set, now available on hire from Instrument Rentals, has all the facilities needed for the rapid in-field testing of transmitters, receivers and duplex R.T. links in one convenient unit.

The test set is suitable for all types of FM, AM, and phase-modulated mobiles and base equipment, up to a frequency of 1GHz and a CW output power of 30W; power levels of up to 100W may be measured for short periods. Speed of measurement results from the use of microprocessor control; for instance, a simplex transceiver may be checked in under three seconds.



For ATE applications, or when a link is required to a PC, all functions except on/off may be remotely controlled via the integral IEEE-488 GPIB interface.

Details from: Instrument Rentals, Dorcan House, Meadfield Road, Langley, Slough, Berks SL3 8AL.

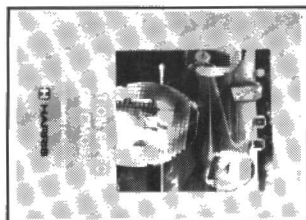
Compact switching

Norbain Electro-Optics Ltd has launched a new series of low-cost compact switching relays, originally designed for the automotive market, which provide an economical solution to low voltage, high current switching applications such as in alarm circuits.

Designated the ZC Series and manufactured by Schrack, the new relays offer a range of contacts including a special contact suitable for switching 6 x 21W lamp loads.

Featuring a contact voltage rating of 110V a.c. and a mechanical life of $\geq 10^7$, the ZC Series has operate and release times of ≤ 10 within an ambient temperature range of -40°C to +80°C.

Details from: Norbain Electro-Optics, Boulton Road, Reading, Berks RG2 0LT.

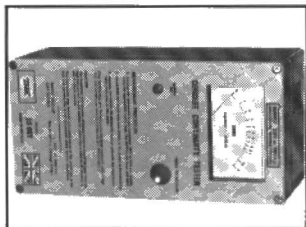


Rad-hard CMOS brochure

A new brochure on radiation hardened CMOS technology is available from Harris. 'Radiation Effects on CMOS' describes the importance of radiation hardened semiconductors in many of today's high-tech systems for commercial, industrial and defence applications.

A new concern for radiation-resistant tactical weaponry is addressed in the book by describing in detail how far major systems can be protected and from what types of radiation. The brochure explains the radiation hardening process, defines types of radiation, and discusses the major concern in CMOS—ionization radiation.

Details from: Harris-MHS Semiconductor Sales Ltd, Eskdale Road, Winnersh, Wokingham, Berkshire RG11 5TR.



15th Edition tester

IEE Wiring Regulations 613.3 and 613.2 define the test requirements for 'Continuity of protective conductors' and 'Continuity of ring final circuit conductors' while appendix 15 gives suitable standard methods of testing.

25CCT, a new conduit continuity tester from TMK Test Instruments, meets these 15th Edition requirements and is therefore ideal for measuring the impedance of protective conductors where part of the protective conductor is a ferrous material. This new instrument, designed and manufactured in the UK, is also extremely useful for ring main measurements and ascertaining earth fault loop impedance (E.F.L.I.).

Details from: Harris Electronics, 138 Grays Inn Road, London WC1X 8AX.

New source for Texas optoelectronics

Texas Instruments, long-established manufacturers of optoelectronic products, have ceased production of their avalanche photo diodes, high power GaAs infra-red diodes, transimpedance amplifiers and hermetic displays range of products. This entire opto range operation has been taken over by Texas Optoelectronics Inc, whose products are available in the UK exclusively from GCA Electronics.

Former TI staffman Mike Bender has joined the company, which can offer the entire former TI optoelectronics range, including those which conform to the various military standards. The company also intends to continue the ongoing development of these devices and to produce new products in the near future.

Details from: GCA Electronics Ltd, Unit 2, Gt. Haseley Trading Estate, Gt. Haseley, Oxon OX9 7PF.

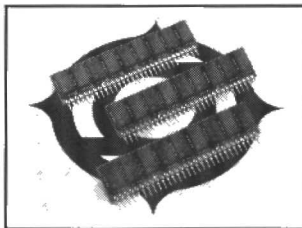
DRAM modules from Hitachi

Hitachi, the largest supplier of memories in Europe, has introduced five new DRAM memory modules (including both pinned and socket types) which save board space and dramatically increase memory density.

The modules are all available with three variations of speed, 120, 150 and 200ns. The DRAMs are all PLCC versions, mounted on an epoxy p.c.b. with either edge connectors for socketing or pins for mounting upright.

The major advantage of modules is that they allow high density packaging without the need for investment in surface mounting equipment. The five new modules allow $\times 4$, $\times 5$, $\times 8$ and $\times 9$ organisations which give flexible word-bit configurations.

Details from: Hitachi Electronic Components (UK) Ltd, Hitec House, 221-225 Station Road, Harrow, Middlesex HA1 2XL.

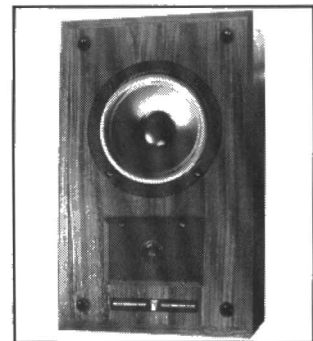


Microprocessor test instrument

New from Gould Electronics is the K115 logic analyser, designed for design, debug and test in microprocessor applications. It provides 32 or 64 channels at 20MHz for state and timing in 8-, 16- and 32-bit applications and a direct link to either four or eight channels at 5 nanoseconds, or eight or 16 channels at 10ns.

A major feature of the K115 is the ability to go from state to timing and back on the main channels simply by pushing a button, thus avoiding the need to reconfigure the hardware.

Details from: Gould Electronics Ltd, Roebuck Road, Hainault, Ilford, Essex.



Woofers and tweeters developments

The popular model 18 speaker is a firm favourite with domestic buyers and many recording studios who use them as desk monitors, while the AR8 was conceived as a more cost-effective alternative to the popular 18. They have now been improved.

The improved versions from Teledyne have been designed by carefully engineering woofers and tweeters to have intrinsically low coloration and even, well-controlled frequency responses.

The woofers' carefully-designed carbon-loaded polypropylene cones, selected surrounds, dust caps and magnet assemblies provide both units with responses which are very flat up to the crossover area, where they roll off naturally and gently. So, because there are no uneven response trends to compensate for and no requirement to 'roll off' the woofers at high frequencies, there is no need for crossover components of any kind.

Details from: Teledyne Acoustic Research, High Street, Houghton Regis, Dunstable, Beds.

WHAT'S TO COME...

After integrated circuits, integrated mechanics

Engineers have started to use the techniques of semiconductor manufacture to produce mechanical microstructures. The production of miniature mechanical devices has reached the practical limits of miniaturisation using traditional production methods, machining, stamping, welding, soldering, hand assembly, etc. The methods used in fabricating i.c.s are providing a solution to the manufacture of certain microminiature devices. The first devices being constructed in the research labs using these techniques are sensors. The kind of sensors produced so far include accelerometers, pressure sensors, strain gauges and even gas chromatograph.

These mechanical devices are all fabricated on blocks of silicon using the techniques of photomasking, etching and deposition developed for i.c. manufacture. Silicon is used as a substrate for two reasons, first because the methods used in fabricating devices with this material are very well known and secondly because it allows any associated electronics to be fabricated on the same silicon slice.

Much of the advanced research into integrated mechanics is being carried out at Stanford University in California, although several Japanese research centres and Delft University in Holland are now starting work in this area. This is an area of research in which we can expect to see very considerable advances over the next decade.

Amorphous Silicon Devices

Researchers at the university of Dundee are making significant advances in the development of semiconductor devices using amorphous silicon. Amorphous silicon has potentially major advantages over crystalline silicon and gallium arsenide. It is much cheaper to produce, can be deposited onto a wide range of different substrates in films as thin as 1 micron and over quite large areas. The amorphous silicon is deposited onto the substrate by decomposing silane gas in a plasma. The resulting film of silicon can be doped by adding small

amounts of phosphine or diborane gas to the silane in order to produce n-type or p-type layers. The resulting amorphous silicon layers have no ordered crystalline structure and only have semiconducting properties because the silicon is alloyed with hydrogen as a result of the silane decomposition.

The Dundee University team have developed the equipment necessary to produce amorphous silicon devices and amorphous silicon FET devices, these are likely to find immediate application in the production of addressable liquid crystal display panels. They have also demonstrated a non-volatile memory based on a p-n-i configuration.

New techniques required for 4Mbit memory chips

Texas Instruments, Toshiba and NEC have all recently demonstrated preliminary laboratory versions of 4Mbit dynamic random access memory chips. The design and fabrication of these super memory chips, each with over 8.5 million components contained on a one cm square silicon chip has posed a whole new and often very complex range of problems for chip designers. The main problem is that in order to retain fast access time it is essential to keep the chip fairly small. This is achieved by reducing the circuit geometries. In order to produce 4Mbit DRAMS 1 micron geometry CMOS will be used. However, DRAMS retain their memory contents by retaining a charge on a capacitor fabricated in silicon on each individual memory cell. With larger geometries and planar fabrication such as capacitor with the required capacitance (about 50fF) does not pose a problem. The solution adopted by designers has been to construct capacitors vertically within the silicon slice creating a so-called 'trench capacitor'. This approach considerably reduces the surface area of the chip occupied by capacitors and therefore allows the far higher component densities essential for fabricating 4Mbit and larger DRAMS. These 4Mbit DRAMS will be on the market within a couple of years, and already the R and D departments are looking at the next challenge—64Mbit DRAMS.

New capacitors used as energy storage devices

A new technique has been developed for making high energy density capacitors. This technique promises to allow them to be used as very economic replacements for NiCad batteries in energy storage applications requiring low drain, such as CMOS RAMs, microprocessors and timers. The devices are known as DLCs or Double Layer Capacitors and exhibit an energy density of up to 500 times that of a standard aluminium electrolytic capacitor. This high charge density allows a 1 farad capacitor to be constructed which has a volume of only about 1 cubic centimetre.

These DLC capacitors have been developed by Sohio Maxcap. The secret of their

construction lies in the replacement of aluminium as the electrode material with activated carbon. The activated carbon has a very high surface area, over 1000 square metres per gramme, and the device's charge capacity is proportional to surface area. The working voltage of such a device is very low, and this necessitates the use of the double layer technique which creates a stack of activated carbon and electrolyte units to achieve the required voltage rating. A 5 volt capacitor requires about six units.

Capacitors fabricated using DLC will find many applications. They are ideal for providing back-up power to CMOS memories. A single 1 farad 5 volt DLC will keep a CMOS RAM card backed up for several months.

POINTS ARISING

PE HOBBY BUS (MAY 1986)

On the circuit diagram and the components list R10 and R11 should read 2K2 not 10k. Also on the circuit diagram and the p.c.b. overlay, R15 and C22 should be transposed, i.e. fit R15 in the place of C22 and C22 in the place of R15.

BOOK REVIEW (APRIL 1986)

The book entitled *Designing IC Circuits with Experiments* was written by Delton T. Horn and not Delton T. Hall, as stated.

COUNTDOWN

If you are organising any electrical, computing, electronic, radio or scientific event, big or small, drop us a line. We shall be glad to include it here. Address details to Countdown, Practical Electronics, 16 Garway Road, London W2 4NH.

NOTE: some exhibitions detailed here are trade only. Please check details and dates before setting out, as we cannot guarantee the accuracy of the information presented here.

Amateur Radio and Electronics Hobby Fair, July 5, 6, Wembley. F

British Laboratory Week, Sept 23–25, Olympia. C

ITAME, Sept 23–25. C

College. B

Milan Fair, Sept 4–8, Milan (Trade only).

Hitachi Electronic Components Summit, June 9, Wembley. D

Official Acorn User Exhibition, July 24–27, Barbican. E

Amateur Electronics Exhibition, July 12–20, Esplanade, Penarth. A

A B.A.E.C. ☎ 0222 707813

B Imperial College ☎ 01-589 5111

C Evan Steadman ☎ 0799 26699

D HPS ☎ 0494 40176

E Editionscheme ☎ 01-394 4667

F Amateur Radio Promotions ☎ 021-421 5516

BOOKS AND LETTERS PAGE

Sir

Whilst I applaud your decision to support the STE bus, to IEEE 1000, I am appalled that you should also introduce your own non-standard 'standard'. You adduce no reason for introducing it, and, with over 150 eight-bit buses in existence, the world really doesn't need another. If you had to have a second, would it not have been better to approach your opposite number at Elektor, for permission to use the Elektor bus? Then you could have built on their good work, in a system that already offers several CPUs, memory and IO cards, instead of encouraging people merely to re-invent the wheel. In the electronics world, the principle of second sourcing is regarded as both desirable and professionally mature, whereas the 'not invented here' syndrome is not just unprofessional, but actively anti-professional.

R. J. Larkin, Dept. of Electronics and Communications Engineering, North London Poly.

Dear Mr. Larkin

Whilst not wishing to comment on projects published in other journals, we would like to point out that many eight-bit buses presently available are extremely limited in the use as a hobbyist project. The Hobby Bus is not designed simply as an eight-bit processor bus but a universal peripheral bus which may be connected to any home micro with the minimum of effort or modification.

In addition, the PE Hobby Bus is able to support both an on-board processor as well as a host micro, thus giving rise to a very flexible and useful system. Can other Hobbyist buses offer so much compatibility whilst retaining flexibility?

Editor

Dear Sir

I wish to make a security lamp that is switched by way of a Passive Infra Red Detector.

I am an idiot. I will also need the circuits as well as the detector. Perhaps one of your readers know of such equipment and also suppliers. Better still why not publish a constructional project for this type of security lamp.

J. R. Atkins, Hurstpier Point, Sussex.

Dear Mr. Atkins

See this issue. By the way—any sceptical readers' who think that this letter is a plant—it's not, honestly. It's just a coincidence.

Editorial

Dear Sir

I have read much about the peripheral equipment that can be attached to my ZX81 to enable me to drive some home-made electronics, but I have not found out how to do the actual attaching.

J. A. Ratcliffe, Cambridge.

Dear Mr. Ratcliffe

There is an edge connector at the back which has all the required connections.

Editor

Dear Sir

I have been unable to find newsagents who stock your Practical Electronics magazine. I used to take it regularly until it got hard to find. Have you ceased publication?

J. S. Smith, Edgbaston, Birmingham.

Dear Mr. Smith

We have not ceased publication—we're still going strong. Recently we have changed our distributors and there should be no further problems regarding availability.

Editor

Dear Sir

With all due respect to your position I feel your answer to the letter from Des M Reed (letter's page PE April 1986) shows a very restricted knowledge of the electronics industry related to recording. Bulk erasers are standard equipment for anyone involved seriously in magnetic recording, and while they are not cheap any quality hi-fi dealer should know of their existence.

I trust you are not going to make a habit of giving such ill-informed answers in future.

Brian Hayter, Principal Technician, Educational Technology Dept, Bulmershe C.H.E.

Dear Mr. Hayter

We are not 'quality hi-fi dealers'. Nevertheless, you are right, we should have informed Mr. Reed that such devices are available. They are, however, rarely available cheaply from normal hi-fi retail outlets.

Editor

Dear Sir

Having 'taken' PE for many years, it is with regularity that one reads of how informative, innovative and absolutely 'essential' reading the periodical is to those of us who have an interest, keen or slight etc.

To this end therefore, I wonder why, during the whole of '85—all 12 issues—PE did not appear to publish even one p.c.b. foil design. 'Tis true, that component overlay designs were featured—some 53 or so I recall. However, an overlay design is not a foil design. Attempting to separate the two for U V artwork, becomes an impossible task, except for the more simple circuits.

I look forward to your comments re the above. Remaining a loyal subscriber meanwhile.

G. I. Hunter

Dear Mr. Hunter

Thank you for your letter of 3rd February. It is an Editor decision with Practical Electronics not to fill the magazine with either p.c.b. foil designs or software listings. P.c.b.s are available from the PCB Service and we will provide any reader who so desires with copies of the foil design for any project.

Editor

Dear Sir

I was very pleased to see that your April issue carried a Photographic Trigger Unit project.

You say that you don't know of anyone who makes a cable type camera release system. Mazof of: PO Box 256, London N19 4SL make a relay camera trigger.
Mr. R. Sahota, Hayes, Middx.

Dear Mr. Sahota

Thanks for your help in this matter, we're sure it will be useful to a number of readers.

Editorial

**OP-AMPS (second edition)
J. Brian Dance—Newnes Technical Books. ISBN 0-600-33372-8
102 pages paperback. £4.95**

Subtitled 'Their Principles And Applications', this book is an updated version of the first edition and thus describes a wider range of devices including programmable, FET input and high power types.

The basic operating principles of op-amps are described in detail with plenty of practical applications to back up the theory. Also included is a section devoted to high power circuits, as high power audio amplifiers are of great interest to many readers.

At the back of the book are three very useful sections. The glossary of terms briefly defines the key words and phrases used in the book and an index of devices refers to the pages in which the devices appear. Finally, a complete cross referenced index makes this publication easy to use as a design aid or reference book.

OSCILLOSCOPES

**Ian Hickman—Newnes Technical Books. ISBN 0-600-33373-6
124 pages paperback. £5.50**

The first edition of this book was published in 1981. There have been many improvements to oscilloscope design since then, largely due to the developments in integrated circuit technology. Digital oscilloscopes are far more popular and widely available. This new edition covers this subject thoroughly.

The book subtitled 'How To Use Them How They Work', describes in depth the principles of real time oscilloscopes, digital instruments and logic analysers. There are many photos and diagrams, essential to understanding the subject.

'Oscilloscopes' is aimed at the user and potential user. It offers advice on how to choose and operate oscilloscopes and highlights the common pitfalls. It should be appealing to anyone wishing to know about the subject, from the student to the technician.

PASSIVE INFRA-RED DETECTOR

BY R. A. PENFOLD

Lighten up with Fresnel lenses and body heat!

ALTHOUGH passive infra-red sensors have been in common use for some time now, they seem to have received relatively little attention in the electronics press. Probably the main reason for this is the lack of availability of suitable sensors. Virtually any semiconductor opto device has good sensitivity at infra-red wavelengths, and many popular opto devices actually have optimum sensitivity in the infra-red part of the spectrum. However, they peak at typical wavelengths of around 0.7 to 1 micron, which is close to the visible light spectrum (about 0.4 to 0.7 microns). For passive infra-red detection it is longer wavelength infra-red radiation that is of interest, and it is wavelengths of around 7 to 14 microns which must be detected.

Passive infra-red detectors do not operate by simply detecting body heat or a lack of it, but by detecting movement of the heat source. This method has to be adopted as the d.c. shift produced by the introduction of a heat source is too small to be detected reliably. Fig. 1 illustrates the basic arrangement that is used, with a fresnel lens being used to divide the area covered by the sensor into zones of good and bad sensitivity. An alternative to the special lens is a simple grille of some kind, but the lens has the advantage of providing much greater sensitivity. Anyone moving across the

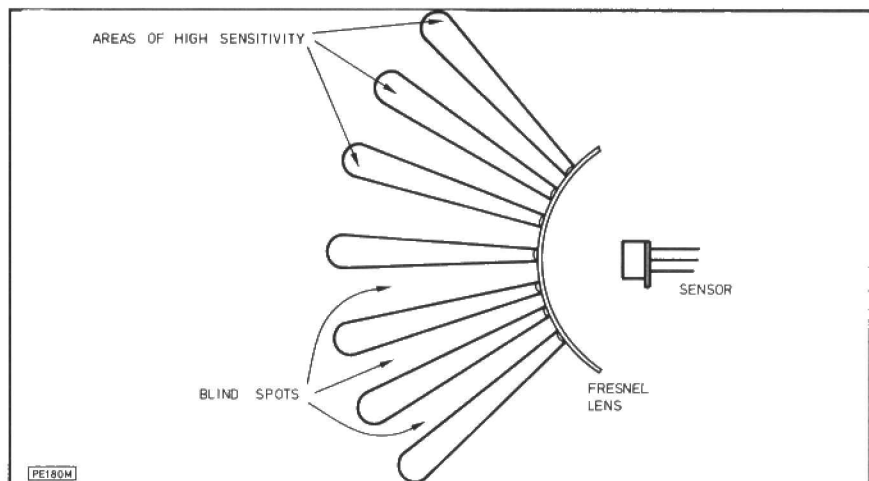


Fig. 1. Basic d.c. shift arrangement

monitored area generates small variations in the output voltage from the sensing device as they move from areas of good sensitivity to the "blind" spots. Provided this signal is above the noise level it can be detected and used to operate a relay or other switching device.

SENSORS

While not being the most widely available of components, passive infra-red detectors, or pyro-electric sensors as they are often called, are available to the home constructor and other small quantity users, as are suitable fresnel lenses. The most widely used type of sensor is the dual opposed type which use the arrangement outlined in Fig. 2. The sensing elements are made from crystals which have the property of producing reverse charges on opposite faces when heated, rather like the more familiar Piezo-electric sensors do when deformed. Having the sensing elements connected so as to oppose one another may seem pointless, since, on the face of it, they will simply cancel out one another and produce no output signal. As far as any background heat is concerned this is indeed the case, but the heat produced by someone moving across the monitored area will be directed first to one element, and then to the other. This gives an output signal

first of one polarity, and then a signal of equal strength but of the opposite polarity. This system gives a relatively strong a.c. output signal to the subsequent circuitry and minimises problems with noise.

The output from the sensors is at a very high impedance, and a built-in field effect transistor connected in the source follower mode provides buffering. The output from the sensor is very low at typically under one millivolt peak to peak, and a high level of amplification is needed in order to bring the signal to a usable level.

SYSTEM OPERATION

The circuit described here was designed primarily with automatic light switching in mind. However, it could easily be adapted for use in other

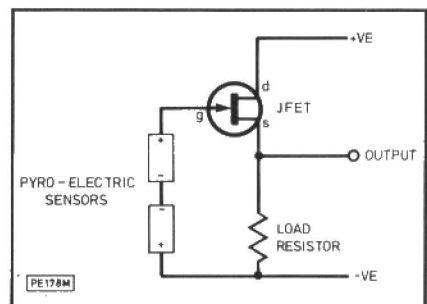
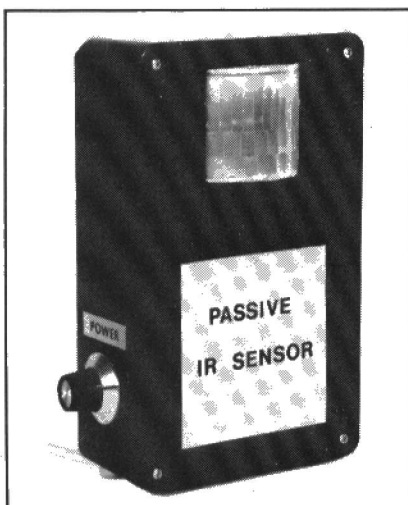


Fig. 2. Dual opposed arrangement

PASSIVE INFRA-RED DETECTOR

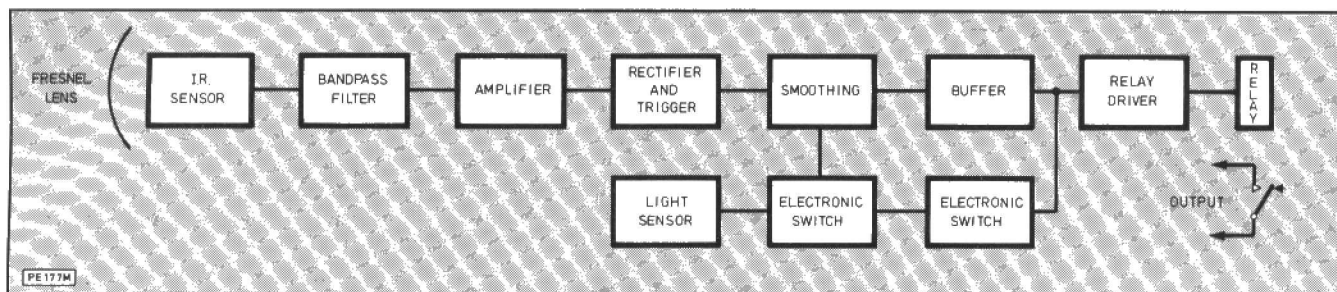


Fig. 3. System block diagram

applications, such as intruder alarms, automatic doors, etc. The block diagram of Fig. 3 shows the various stages which make up the unit.

Obviously the fresnel lens and the pyro-electric sensor appear at the input of the unit, and these are followed by a bandpass filter. Only a very narrow bandwidth is required, and the wanted signals from the sensor are at very low frequencies in the region of 1Hz. By restricting the bandwidth of the system to the minimum requirement any problems with noise that is either picked up by sensor or generated by it are minimised. The next stage is a high gain amplifier which boosts the signal by over 80dB, giving an output of a few volts peak to peak when the unit is activated.

operating continuously when someone is in the room, and to avoid having it continually flashing on and off. The smoothing circuit has a high output impedance, and a buffer stage is therefore used to match it to the subsequent circuit which is a relay driver stage. A pair of normally open relay contacts are used to switch on the light, activate the burglar alarm, or whatever.

The unit as described so far is suitable for many applications, but is less than ideal for automatic lighting control. The problem is simply that it will switch on the light whenever anyone enters the room, even during broad daylight. This problem is overcome by incorporating a light level detector in the design. If the intensity of the ambient light is above a certain thresh-

where it does receive light from outside, but does not pick up a significant amount of light from the controlled lamp. This is not usually a very convenient way of doing things in practice though.

An alternative is offered by this circuit in the form of a second inhibit circuit. This one disables the light detector circuit whenever the lamp is switched on. This prevents the photocell circuit from switching off the lamp and producing oscillation, but it enables the photocell circuit to inhibit the unit if someone enters the room during daylight hours. There is one minor flaw in this arrangement in that the lamp will not be switched off if someone is in the room, and the ambient light level increases to the point where the

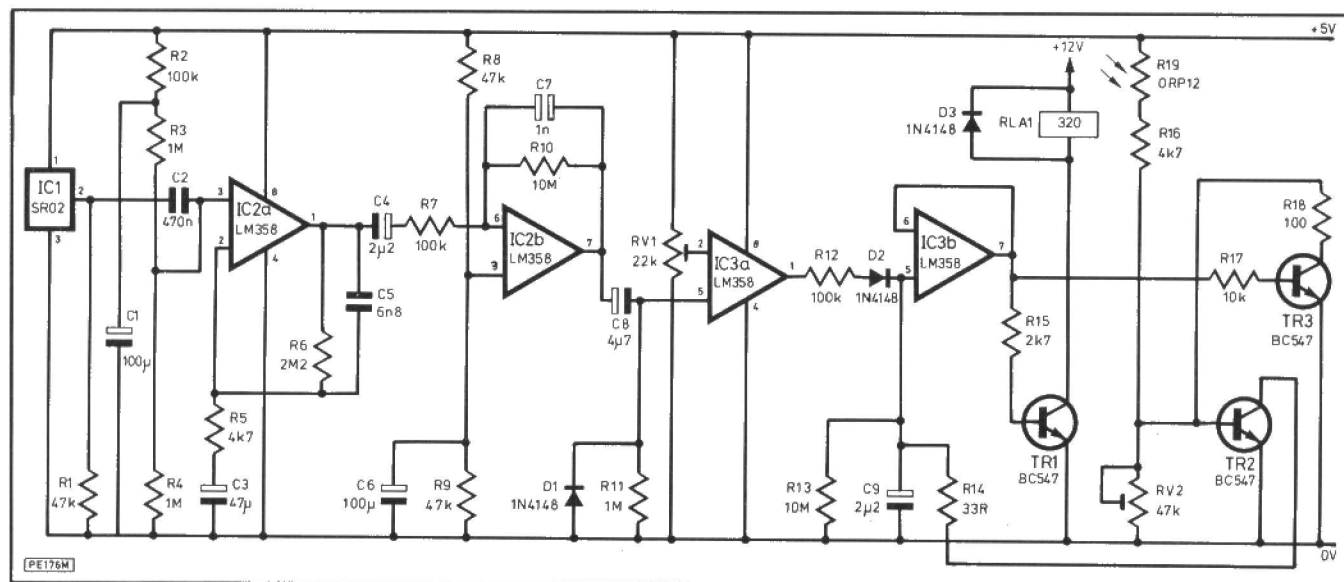


Fig. 4. Main circuit diagram

The amplified signal is rectified and used to drive a trigger circuit. The latter produces a positive output pulse whenever the positive input signal level exceeds a preset threshold level. A smoothing circuit at the output of the trigger circuit has a long decay time of about half a minute, but a much shorter attack time. With no output from the trigger circuit it obviously provides zero output voltage, but with occasional pulses from the trigger stage the smoothing circuit maintains a strong positive output level. The idea of this is to have the controlled light

old level, by way of an electronic switch the light level detector holds the output of the smoothing circuit at zero volts. The circuit is thus inhibited and the light can not be switched on.

This in turn leads to a second problem, which is that of the photocell circuit detecting the light from the controlled lamp, and inhibiting the circuit as soon as the lamp is switched on. This would result in the circuit oscillating with the lamp being switched on and off continuously. The most simple solution to this problem is to have the photocell remotely located

lamp-light is superfluous. However, this is something which is unlikely to occur in practice anyway.

CIRCUIT OPERATION

The main circuit of the unit is shown in Fig. 4, but the mains power supply circuit is shown separately in Fig. 5.

IC1 is the pyro-electric sensor, and R1 is the discrete load resistor for its source follower buffer stage. The SR02 requires a supply voltage of between 2.2 and 10V, and in this case it is powered from a stabilised 5V supply. It has a 50/50 degree field of view.

The output from IC1 is amplified by a two stage amplifier, and this has IC2a as a non-inverting amplifier and IC2b as an inverting type. These two stages have voltage gains of approximately 53dB and 40dB respectively. The bandpass filtering is incorporated in these two amplifiers, with the highpass filtering being supplied by the d.c. blocking capacitors. The highpass filtering is obtained by including C5 and C7 in the feedback circuits.

IC3a functions as the rectifier and trigger stage. IC3a is really just operating as a voltage comparator, with R11 biasing the non-inverting input to the 0V supply and VR1 providing the inverting input with a preset reference voltage. This sends the output of the trigger stage low under quiescent conditions. If the unit is activated, and the output signal from IC2b is strong enough, on positive output half cycles the input to the non-inverting input will take this input positive of the inverting input, and the output will trigger to the high state until the voltage at the inverting input subsides below the reference potential. VR1 is given a setting that provides good sensitivity but which does not result in the unit being prone to spurious triggering.

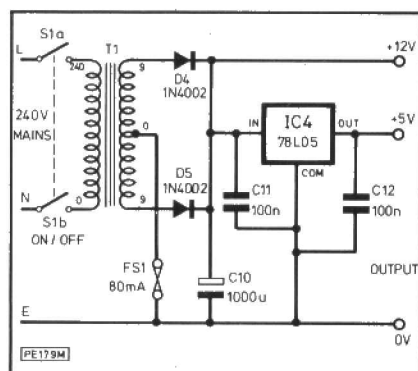


Fig. 5. Power supply

The smoothing circuit consists of R12, D2, R13 and C9. The buffer stage is a conventional operational amplifier non-inverting type (IC3b). TR1 is the relay driver transistor and it operates as a simple common emitter switch. D3 is the usual protection diode. R19 is a cadmium sulphide photoresistor, and if the ambient light level is strong enough it biases TR2 into conduction. TR2 then clamps C9 via current limiting resistor R14, and prevents any significant charge from accumulating on C9. VR2 is the sensitivity control, and it enables the light level at which the inhibit circuit comes into operation to be varied over very wide limits. TR3 is switched on when the relay and relay driver are activated, and it then practically short circuits the base of TR2 to the 0V supply rail, so that this device can not switch on.

The power supply circuit must provide a well smoothed and regulated output at +5V and supply a few milliamps to the main circuit, and also supply a +12V output for the relay which has far less stringent smoothing and regulation demands. The circuit is a conventional type using push-pull rectification and monolithic voltage regulator IC4 to provide the +5V output. The relay is fed direct from the unregulated but smoothed supply. This might fall to somewhat less than 12V under full load, but it will still be adequate to drive the relay properly (which requires a minimum drive potential of 9V). Note that FS1 must be an antisurge type and must not be of the more common "quick-blow" variety (which would almost certainly "blow" as C10 initially charged up at switch-on).

CONSTRUCTION

The exact form that the unit takes must depend to some extent on its intended application, but whatever its proposed use the printed circuit layout of Fig. 6 should be suitable. Construction of the board is largely straightforward, but there are a few points which are worthy of note.

As with any project that utilizes a printed circuit mounting relay it is definitely advisable to use the specified component. Other types, although they may be electrically perfectly suitable, are unlikely to have the same base layout, and would therefore require some modification to the board or would have to be mounted off-board somehow. The specified component can handle up to 10A at the mains voltage and with a resistive load, or 3A with an inductive load. From the electrical stand-point any relay which has a 12V coil with a resistance of about 300 ohms or more is suitable, provided it has contacts of adequate rating for your application of course.

It is essential that C3, C4, and C8 are very good quality components, and tantalum capacitors are used in these positions on the prototype. Low leakage radial electrolytics should be equally suitable though. R19 can be an ORP12, MPY76C, or virtually any cadmium sulphide photocell in fact, as VR2 gives sufficient adjustment range to render the precise characteristics of the cell unimportant. In some applications the inhibit circuit will be unnecessary, and R19, R14, R16 to R18, VR2, TR2 and TR3 can then be omitted.

A plastic box which has approximate outside dimensions of 180mm by 100mm by 55mm makes a good housing for this project. It is used vertically, with the printed circuit board mounted on the rear panel so that IC1 is as close to the top of the case as possible, and centred left to right. This leaves suffi-

COMPONENTS...

RESISTORS

R1,R8,R9	47k (3 off)
R2,R7,R12	100k (3 off)
R3,R4,R11	1M (3 off)
R5,R16	4k7 (2 off)
R6	2M2
R10,R13	10M (2 off)
R14	33
R15	2k7
R17	10k
R18	100
R19	(l.d.r.) ORP12 or MPY76C

All resistors 1W 5% carbon

POTENTIOMETERS

VR1	22k sub-min hor preset
VR2	47k sub-min hor preset

CAPACITORS

C1,C6	100µ 10V radial elect (2 off)
C2	470n miniature polyester
C3	47µ 10V radial elect or tant
C4	2µ2 25V radial elect or tant
C5	6n8 miniature polyester
C8	4µ7 25V radial elect or tant
C9	2µ2 25V radial elect
C10	100µ 16V radial elect
C11,C12	100n ceramic (2 off)

SEMICONDUCTORS

IC1	SR02 IR detector
IC2,IC3	LM358 (2 off)
IC4	78L05 (+5V 100mA regulator)
TR1-TR3	BC547 (3 off)
D1-D3	1N4148 (3 off)
D4,D5	1N4002 (2 off)

MISCELLANEOUS

S1	Rotary mains switch
FS1	80mA antisurge
T1	9-0-9 volt 100mA secondary, mains primary
RLA	320R 12V coil, 10 C/O contacts, PCM (Maplin YX97F)

Case about 180 × 110 × 55mm; printed circuit board PE115; CE24 fresnel lens; printed circuit fuse mounting clips (2 off); control knob; 8-pin d.i.l. i.c. holder (2 off); mains lead and plug; connecting wire, solder, etc.

The CE24 lens, SR02 IR sensor, and MPY76C are available from Chartland Electronics Ltd., PO Box 83, Cobham, Surrey, KT11 2QB.

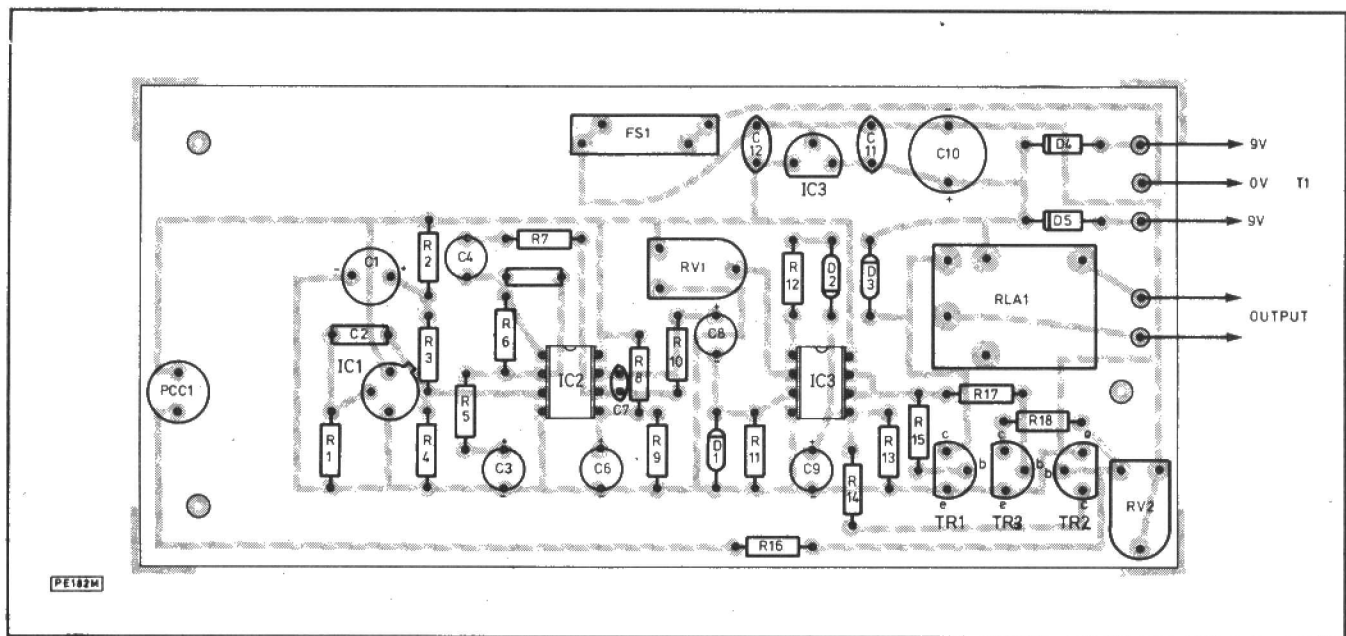


Fig. 6. P.c.b. constructional details

cient space for the mains transformer to be mounted just below the circuit board. A soldertag is fitted on one of T1's mounting bolts, and the mains earth lead must be connected to this. S1 is fitted on the left hand side panel, near the bottom of the unit. If the unit is to be wall mounted the holes for the mains lead and the output lead should be drilled in the base panel, but if it is to be free-standing they must obviously be made in one of the side panels.

The only awkward aspect of construction is the mounting of the fresnel lens. As supplied this is a flat piece of flexible plastic which must be given the correct curvature by its mounting. Experiments with various types of mounting mostly proved to be less than totally reliable, and the method which seems to work best is the most simple one. A cutout measuring 47 millimetres wide by 45 millimetres high is made in the front panel, and this should be positioned such that IC1 is beneath the centre of the cutout. The sides of the cutout are bevelled on the reverse side of the panel at about 45 degrees. Using a good quality general purpose adhesive the side edges of the lens are then glued to these bevelled edges. The lens can be carefully curved to roughly the right shape prior to fitting it in place, and once fixed it seems to retain the correct curvature. Note that the lens is designed to have the smooth surface facing outwards. If desired, some plastic or card can be cut to shape and used to fill in the gaps above and below the lens. Apart from giving a neater appearance, this seals the unit from any air turbulence which might encourage spurious triggering. IC1 should be about 30 millimetres below the front of the lens, and spacers

must be used when mounting the printed circuit board so that IC1 is brought to the correct position. This will be easier if the leads of IC1 are not cropped short, as otherwise a lot of spacers might be required.

The lens will probably allow adequate light for R19 to pass through into the case, but if necessary a hole can be drilled just above the lens to permit additional light to reach R19.

fully, and the normal safety precautions should be observed.

ADJUSTMENT AND USE

Start with VR2 set in a fully clockwise direction so that the inhibit circuit is disabled, and with VR1 at a roughly middle setting. At switch-on the unit will not function as it takes a minute or so for the capacitors to settle

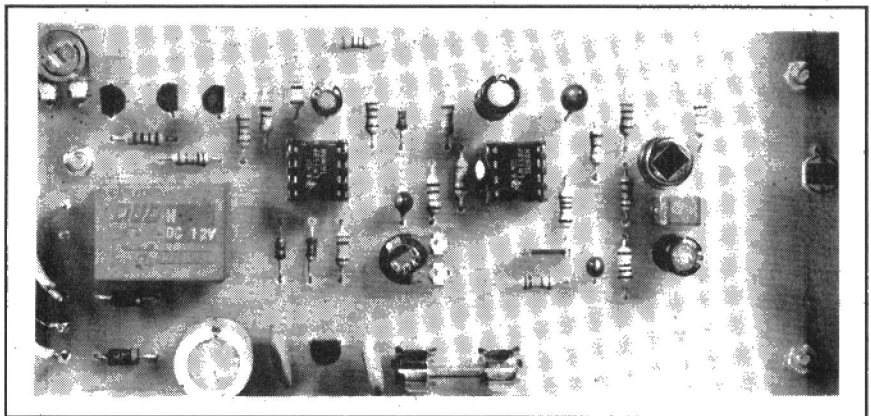


Photo 1. P.c.b. details

To complete the unit the small amount of hard wiring is added. In some applications (intruder alarms for instance) the switching action of the relay will be all that is required, and a twin lead can be used to wire the unit into the alarm or other circuit. Where the unit is to be used to control a mains load it is probably best to wire things up so that the output from the unit is a switched mains supply, including an earth lead in cases where the controlled equipment requires it. It is quite easy to wire up the unit in this way, but whenever dealing with the mains supply it is wise to proceed very care-

down and take up their normal working charges. This is a consequence of the high gain and low operating frequency range of the amplifiers in the unit, and as the unit will normally be left running continuously, or at least for long periods of time, it is not really a major drawback. Once the settling time has elapsed the unit should activate the relay when anyone goes within the monitored area. The relay should remain switched on while someone stays within this area, but bear in mind that it is movement rather than presence that is detected, and someone remaining still for half a minute or so

PASSIVE INFRA-RED DETECTOR

might let the unit return to the "off" state. Adjusting VR1 in a clockwise direction gives increased sensitivity, but adjusting it too far will simply result in frequent spurious triggering, or the relay failing to switch off when the monitored area is left vacant. The final setting of VR1 therefore has to be a compromise between sensitivity and reliability, and a little experimentation should soon reveal a suitable setting.

When the main circuit is functioning properly VR2 can be backed-off to bring the inhibit circuit into action. The easiest way to give VR2 the correct setting is to first have the ambient light at the lowest level which must activate the inhibit circuit. With one lead of R18 temporarily disconnected (remembering to disconnect the unit from the mains before working on it) back-off VR2 just far enough to switch off the relay.

Careful thought needs to be given to the positioning of the unit. The pyroelectric sensor seems to be totally immune to light, but it should not be positioned in direct sunlight (which has a significant content in the long infra-red part of the spectrum). Neither should it be placed where radiators or other heat sources are likely to give problems. Remember that it is most sensitive to someone moving across its field of view, and has

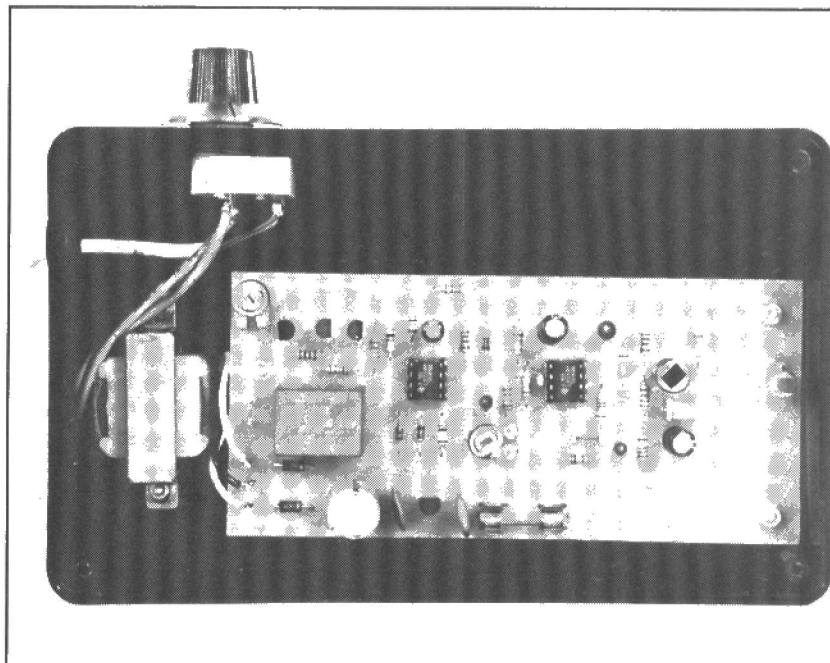


Photo 2. Internal construction details of the Passive IR detector showing the p.c.b. and transformer mounting details

minimum sensitivity to someone moving directly towards or away from the unit. Sensitivity is quite good, and if positioned at a height of about 1.5 to 2 metres in the corner of a room, it should cover practically all of even a

large room. The prototype worked well in a room measuring approximately 7 metres by 4 metres. Units of this type are less than ideal for use outside where air currents can cause spurious triggering.

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THE LEADING EDGE

BY BARRY FOX

Compact competition increases as demand exceeds supply

TO THE casual observer compact disc, the five inch laser-read digital audio gramophone record, looks like a licence to print money. After a slow start three years ago, five million players have now been sold round the world. Discs are in short supply and sell like hot cakes even though they cost over £10 each.

There are now ten pressing plants around the world in full production, with several more just coming on stream. Polygram's plant in Hannover, West Germany, is the largest in the world. Polygram admits that even with this year's production capacity of 50 million discs from Hannover alone, it is still a seller's market. "Marketing is increasing more rapidly than capacity," says Dieter Soine, in charge of production at Hannover. "It takes a minimum of six weeks to turn orders round".

So far city money feels safe in investing in compact disc. But the situation could soon change. New plants are popping up like mushrooms. Britain's only plant so far, Nimbus in Wales (with six million discs per year capacity) is opening a second Welsh factory, with capacity aimed at between 20 and 25 million a year. Thorn-EMI's plant at Swindon, built to press the largely unsuccessful VHD videodisc format, was scheduled to start producing saleable CDs by the end of April with a formal opening in May.

Disctec, a spin off from PR Records, is now installing clean room and pressing equipment in a new building on the Southwater Business Park at Horsham in West Sussex. Disctec raised £9 million from Investors in Industry, The Robert Fleming merchant bank, the Prudential and Coal Board Pension Fund. Phil Race of Disctec says he hopes to be producing at a rate of four million a year by September, and doubling next year. He could well be right, because the plant is run by Jim Johnston who built and de-bugged Thorn-EMI's factory.

Disctec is sufficiently confident to be advertising in the electronics press for staff to fill sixty jobs.

Mysteriously, head-hunting firm IPS is offering at least £60,000 a year for a director of operations in another, unnamed, plant. The right man for the

job could get £100,000. Nimbus and Disctec deny placing the ad. It could be Philips which is secretly converting part of its under-used Laservision videodisc plant at Blackburn to CD production. Or it could be yet another British firm planning to move into compact disc.

All the Japanese pressing plants are currently increasing production, for instance JVC is aiming for thirty million discs a year and Denon is nearing twenty-five million. Polygram has the largest CD factory in the world at Hannover. It was the first in the world because Polygram is 90% owned by Philips who invented the CD system (Siemens has the other 10%). Sony, who joined forces with Philips and improved the system, has a factory in Japan and another in Indiana, US. It was originally a joint venture with CBS, but Sony tired of the high reject rates, bought out CBS and now runs it solo. Sony has just struck a deal with the Austrian government to build a new factory near Salzburg. MPO has a factory in France and Sonapress has converted its video disc facility in Germany to CD, using Japanese presses. Tape firm ICM in Switzerland has bought CD presses from Philips and Polygram. More presses have been sold to Korea. Warner talks about pressing in Germany and America. And so it goes on...

Pressing discs are more difficult than making microchips—the data pits for CD are much smaller than the circuit lines on an IC. Anyone still only thinking about disc production is already too late, unless they are a large company able to withstand losses as they climb the learning curve. By the time any new venture is on stream disc supply will be matching demand and the rich pickings (factories currently charge £2 a disc pressed) will be gone. Polygram admits to a reject rate of 15%, even after nearly five years of experience. Some factories are throwing away more than they sell. Sony claims a reject rate of between 10% and 5% for its Japanese plant.

Player production is comparatively easy. The heart of a CD player is a very small motor-driven turntable, with solid state laser optics mounted on a tiny swinging arm and a package of half a

dozen highly integrated circuit chips. All come from Japan, or from Philips and its British subsidiary Mullard (Philips still has to buy its solid state lasers from Sharp in Japan). So CD is ideal for mass production.

This is why the coming of CD has shifted the balance of power in the hi fi industry away from small specialist firms to the major manufacturers. And that is why the major manufacturers wanted CD—they had lost their share of the hi-fi market to small firms.

The best a specialist hi fi firm can do is buy a package of optics and electronics from Philips (or the Japanese) and build it into a different box. Some firms even use the Philips box and a different label. Amstrad and Binatone sell budget players made from Philips components. Three British hi fi firms are now making specialist CD players. All come from the Cambridge area where most British hi fi firms are.

Meridian, Cambridge Audio and Mission all offer an 'improved' version of the basic Philips package. Because there is nothing that can be done with integrated chips and optics, all these firms seek to improve the sound by modifying, or adding to, the analogue circuitry in the player which works with chips. The main modification is to the filters which get rid of spurious sounds made by the digital processing. But there is dispute over how serious this problem really is.

Philips engineers are tactful, but unenthusiastic, about these modifications to their package. Jos Timmermans of Philips factory in Hasselt, Belgium (which makes 15 000 CD players a day) says he and his engineers have measured and listened to the modified players. They can detect differences in sound created by tweaking the circuits used around the Philips chip set. A slight roll-off, says Timmermans, may "give a softer sound and suit local taste... but it's a niche market".

This is a polite way of saying that tweaked players can disguise the slightly harsh sound you get from less-than-perfect discs. A new chip set due soon from Philips and Mullard will improve the sound without filtering. Needless to say Philips' own factories will get the chips before anyone else. **PF**

BETTER USE OF DRY BATTERIES

PART TWO BY ROD COOPER

We have the technology!
—for cost-cutting dry cell charging

WHY bother to recharge dry cells when sealed NiCd cells are available? Part One last month listed some of the shortcomings of NiCds. These are:

- 1) Much lower capacity (about 50% less than alkaline-manganese dry cells)
- 2) Sealed sintered NiCds discharge themselves rapidly on standing
- 3) Premature failure of NiCds due to dendrite formation
- 4) Fall-off in performance due to electrolyte decomposition
- 5) Electrolyte leakage—the spreading white corrosive deposit found on the tops of NiCds
- 6) Higher initial cost.

For better reliability, better charge retention and superior capacity (in the case of alkaline-manganese) dry cells are often to be preferred. Systems for recharging dry cells have been around for many years, but have never been popular due mainly to the black propaganda put out by the manufacturers, but also due to the fact that cells used to be cheap enough to throw away. The dry cell market is worth about £100 million per year in the U.K. alone, so we can hardly blame the manufacturers for trying to protect their own interests. If recharging were to be generally adopted, this market would shrink to under £20 million per year. The saving in raw materials and industrial effort would be enormous. However, the idea that it is dangerous to recharge dry cells seems to have taken root in the U.K., assisted I am sorry to say by the dissemination of the manufacturers propaganda by the technical press.

It is easy to disprove this notion—simply recharge a dry cell using the circuit in Fig. 9 and note the total absence of danger! Fortunately there is now plenty of other evidence from people who have been practising recharging for several years to show that recharging can be perfectly safe—sometimes achieving 20 recharges per cell.

In this respect the conservation-conscious Japanese are—typically—way ahead of us. In Japan they have *actually made it illegal* for a

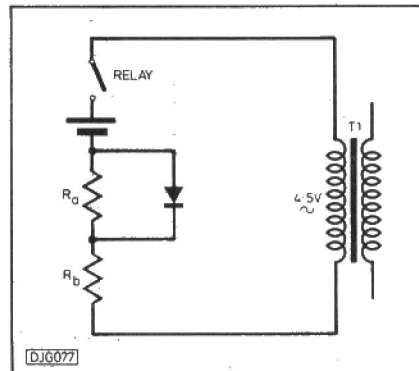


Fig. 6. Biased a.c. current method

manufacturer to claim that dry cells are not rechargeable, following a celebrated court case in 1975. The words "not rechargeable" or "dangerous to recharge" have disappeared from the sides of batteries sold in Japan, but curiously the same products sold in this country still bear this wording, specially for export. In Japan, recharging of dry cells is officially condoned, saving Japan a small fortune in the process. If only we could follow their example in this country—but unfortunately vested interest will ensure this does not happen.

What are the facts? In the U.K. it is said that there exists a danger of explosion if a dry cell is recharged. I will shortly show that this is utter nonsense.

I must make it absolutely clear at this point that there are five golden rules for recharging dry cells, as follows:

- 1) Recharge cells individually, not connected together as a battery. This restricts the technique to single cells—AA, C and D. This is because if a fault developed in one cell, the other cells being charged could be given an excessive current. A constant current technique could be used to overcome this but would be difficult to implement using the method about to be described—the Periodic Current Reversal Method.

- 2) Limit the current, so that if a faulty cell goes short-circuit it cannot dissipate excessive power.

- 3) Limit the time of recharge so that overcharging does not occur.

- 4) Do not allow cells to become fully discharged. For the best results, it is necessary to stop short of full discharge, and recharge fairly soon. Discharged cells that are left for weeks do not accept a recharge. This is because irreversible chemical changes take place inside the cell.

- 5) Most important of all, do *not* use d.c.

The bad effects of using d.c. were detailed in an article in *Wireless World* of August 1955 by R. W. Hallows, and readers who want more information can find this magazine in most reference libraries. Basically, using d.c. results in overheating and also erosion of the zinc electrode, giving erratic results and generally poor figures for the number of recharges possible. In contrast, using a biased a.c. current such as that used in Fig. 6 gives negligible heating of the cell and causes no zinc erosion.

It uses the Periodic Current Reversal (PCR) process already mentioned to keep the zinc in a hard, compact state rather than the spongy form produced by d.c., and is a development of methods used in the electroplating industry for many years to give hard, shining non-dendritic plating of certain metals. PCR consists of applying a small current in the reverse direction to the main recharging current at regular intervals—in the case of Fig. 6 at 10 millisecond intervals as the mains frequency is used. A typical waveform produced by this circuit is shown in Fig. 7. Note that the forward-charge time is less than the reverse-charge time because of the 1.5V pedestal

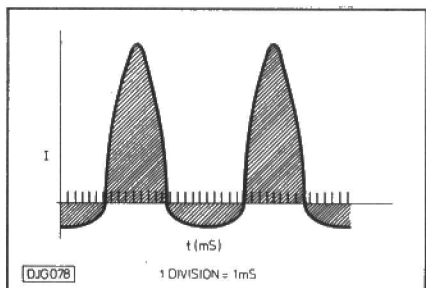


Fig. 7. PCR waveform

BETTER USE OF DRY BATTERIES

voltage presented to the forward current by the cell itself. The ratio of forward to reverse charge is about 4 or 5 to 1.

SAFETY

Recharging is safe provided you follow the rules about limiting time, current and not using d.c., because dry cells from responsible manufacturers have a built-in pressure release system. This fact is not well publicised, probably because it could be abused by non-technical people. Usually it consists of a weak spot in the case which can burst in a controlled fashion if internal pressure becomes too great. There are variations on this theme—for example the release mechanism in the Duracell range is a wax plug in a small release vent at the bottom of the case (Fig. 11) which when forced out allows gases to escape into the bottom of the case and eventually to seep to atmosphere. (The outer case is not air-tight like the inner case.)

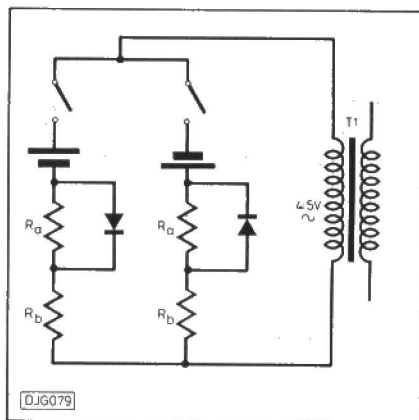


Fig. 8. Balanced-pair charging

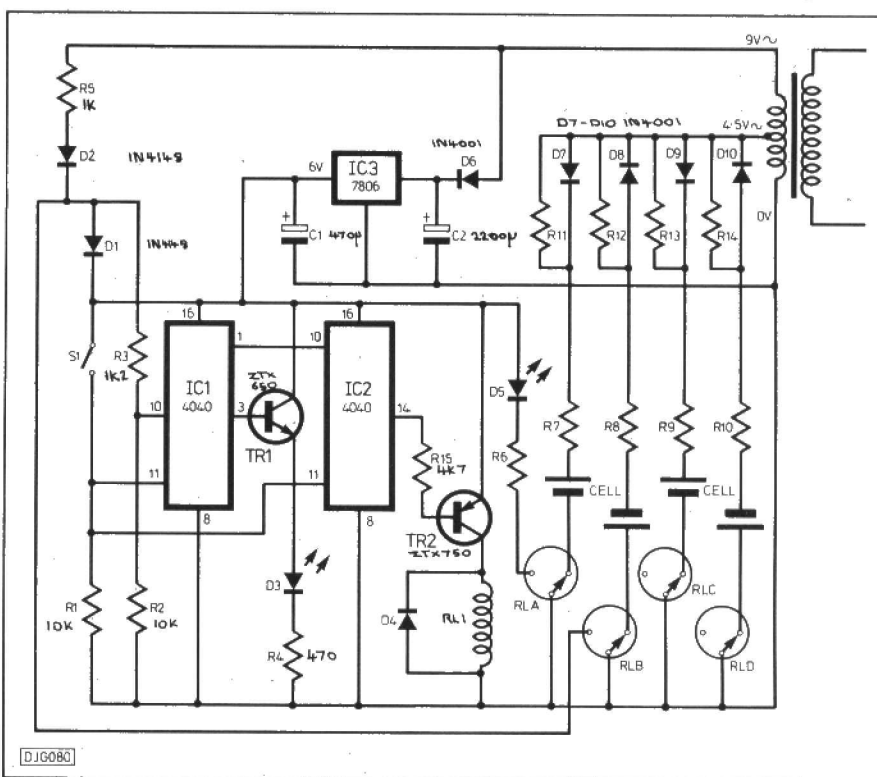


Fig. 9. A practical charging circuit

Clearly the capability of any vent mechanism is limited and would not prevent a cell that had, for instance, been thrown on a fire from disintegrating with considerable force. Why, then, do manufacturers put a safety vent there? It can't be to allow recharging of their batteries! There are two reasons. Firstly if one cell in a battery is accidentally put in the wrong way round, it can be driven in reverse by the other cells, and this can generate gas pressure by decomposing the electrolyte. Secondly, if one cell in a bat-

tery is exhausted before the others, the cells that still have some charge left can again drive this cell in reverse with the same results. This often happens when half-used cells are put in with fresh cells, and would lead to frequent accidents if it were not for the safety vent.

However, having a safety vent does provide a convenient safety factor for recharging if the proper methods are used. I have done some experiments to show what outrageously high currents need to be used to cause cell damage. The results are shown in Photos 1 and

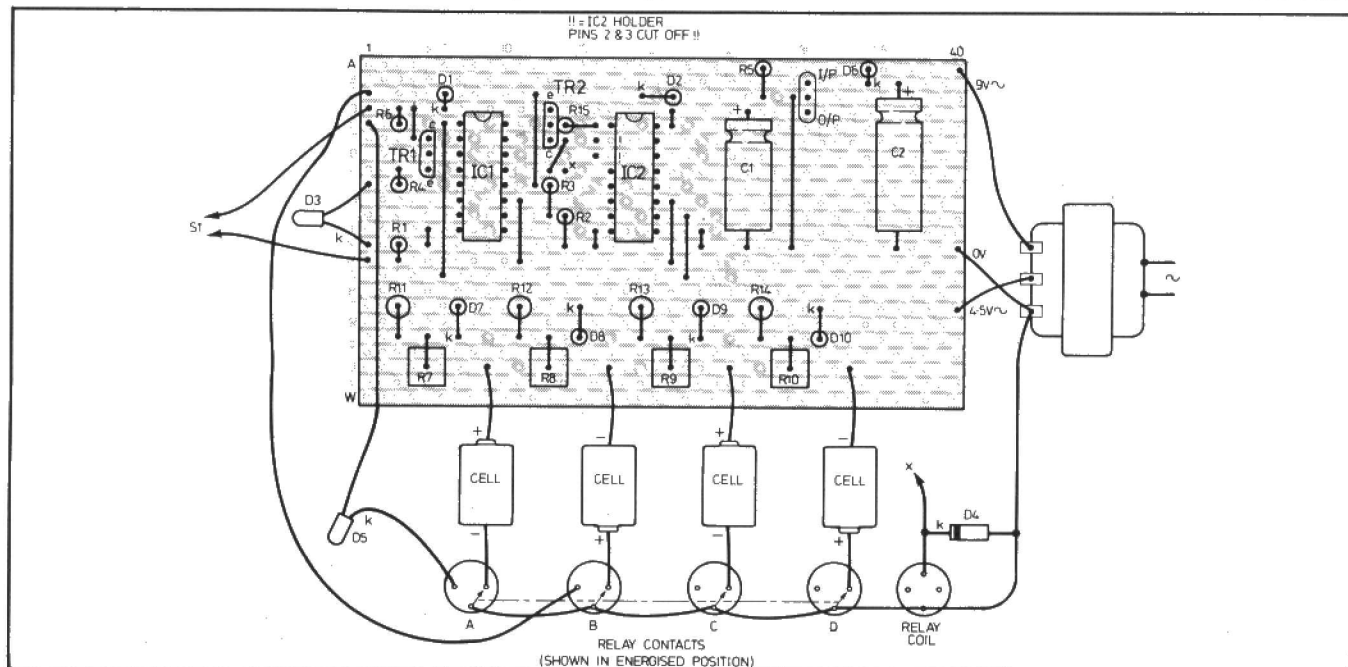


Fig. 10. Stripboard layout

BETTER USE OF DRY BATTERIES

2 and they show that recharging is basically a very safe process.

PRACTICAL RECHARGING CIRCUIT

The circuit shown in Fig. 6 is unbalanced and gives an undesirable d.c. component in the transformer. Cells are therefore charged in balanced pairs as shown in Fig. 8.

The complete charger is shown in Fig. 9. The component values are for D size ordinary zinc-carbon cells, and Table 2 gives values for other sizes. The circuit works as follows; IC1 and IC2 form a timing circuit to limit the charging time to about 12 hours. This period was chosen as it gave the possibility of overnight charging without pushing the charge-acceptance of the average zinc-carbon cell too far. The CA4040 used for IC1 and IC2 is a 12-stage binary counter, and two are cascaded to give a 24-stage counter.

If IC1 is fed with a 50Hz signal derived from the transformer secondary, then the output from stage 22 will change state every 11 hours 39 minutes. The 50Hz signal is obtained via R5 and D2. D1 prevents the input from exceeding the line voltage, assisted by potential divider R3 and R2. Switch S1 is a momentary push-button type which starts the count. The output of IC2 is low when S1 starts the count, turning transistor TR2 hard on and energising the relay. This relay is a 4-pole change-over type. The cells are connected to the charging circuits D5, R11, R7, etc.

At the first change of state after 11 hours 39 minutes, the output goes low, turning the relay off, stopping further charging. To prevent the next change of state turning the relay back on again in another 11 hours 39 mins, one set of the relay contacts is used to ground the input and stop the count. Another set of contacts is used to light an l.e.d. (D5) to show that charging is complete.

TR1 and D3 form a flashing indicator showing that charging is in process and is taken from output 5 of IC1, giving a period of 0.32 seconds. A centre-tapped mains transformer is used to power the charging circuit and the control circuit separately. This enables the power dissipated in the charging circuit to be kept low by using the lower voltage tap.

One point of practical construction; keep the cell holders separate from the electronics. Then if a faulty cell leaks, no damage will be done. A strip-board layout of the circuit is shown in Fig. 11.

The values of the charging-circuit resistors in the table of Fig. 7 are for ordinary zinc-carbon cells. The energy delivered to each cell with the values given is less than the rated capacity, thus avoiding overcharging. If you look

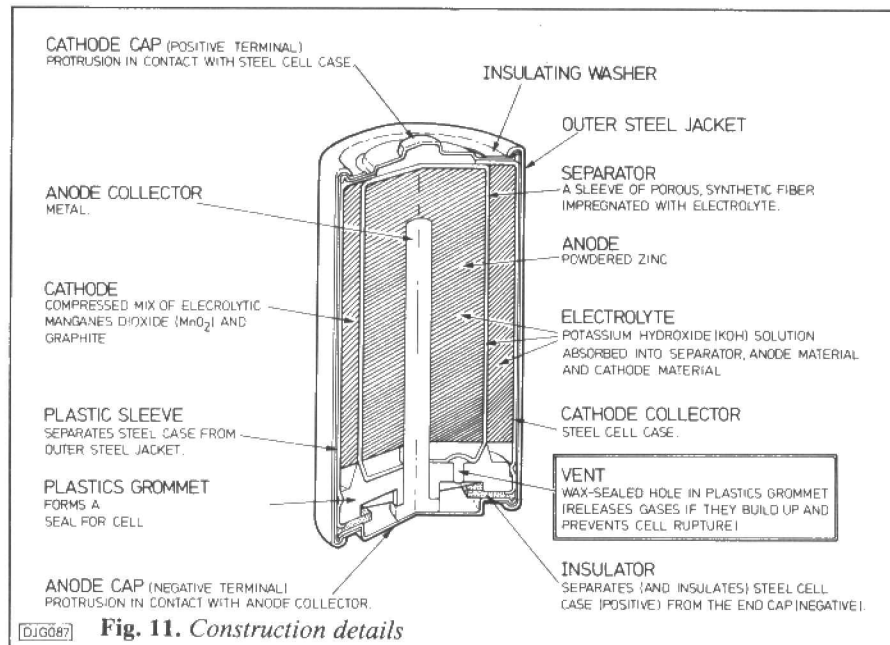


Fig. 11. Construction details

back to rule 4 you will recall that some capacity had to remain in discharged cells for the recharging process to be effective, so when this is taken into account, a nearly-full charge can be expected for a zinc-carbon cell.

For alkaline-manganese cells, the energy delivered will fall far short of the cell capacity since these cells have so much more to start with. So, these cells need a much longer recharge time. This is easily accomplished by connecting

Photo 1. Cells 1 to 4 are different types and make of cell which have been overcharged by a factor of ten times to show how safe it is. The recharge current was 1 amp (five times that recommended) for 24 hours (twice as long as that recommended). To make the test more severe, plain smoothed d.c. was used. Result: no sign of leakage, no sign of splitting or bursting. Cell No. 2 developed a slight bulge after 8 hours but nothing further happened. This cell was sectioned and compared with an uncharged cell.

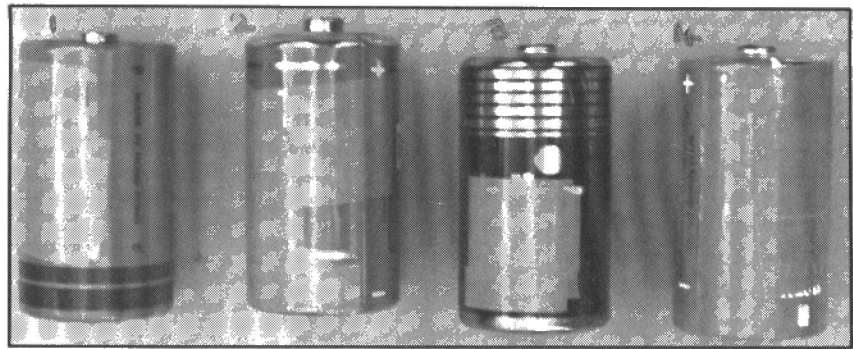


Photo 2. Another set of cells was charged at 0.2 amp using PCR for 5 days, an overload of ten times the recommended rate. No sign of leakage or splitting of the case was seen. A sectioned view of one of these cells shown below on the right compared with an uncharged cell on the left, confirms no distortion of the case or internal components.

As all these tests have been repeated many times it is safe to say that recharging with PCR at 1/10 of the charge rate used is harmless provided the rules set down in the text are adhered to.

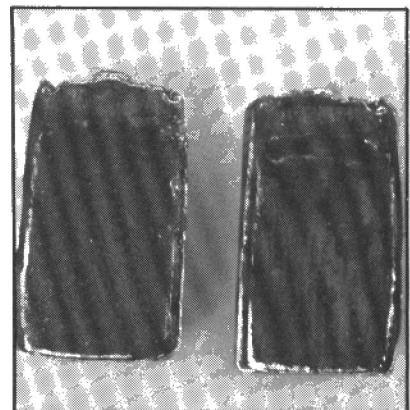


Table 2. Alternative component values for various types of cell. It is advisable not to alter any component values unless specified in the text.

Cell size	D	C	AA	
R7,R8,R9,R10	6R8	12R0	47R0	5W
R11,R12,R13,R14	68R	120R	470R	2W

BETTER USE OF DRY BATTERIES

the base of TR2 via R15 to pin 15 of IC2 instead of pin 14. This doubles the timing period to 23 hrs 18 minutes—about a half-charge for an alkaline cell. This is fine for topping-up half-discharged cells. If you have nearly fully discharged the cell, then you can use pin 1 of IC2 for a 46 hr 36 minute charge, giving a full or near-full recharge.

It is not recommended to alter the charging-circuit resistors. **PE**

A PRACTICAL CASE STUDY

The two CB radios in Photo 3 illustrate what can be used by combining the methods described in Part 1 and Part 2 of this series of articles. The radio on the left is powered by a PP3 alkaline-manganese dry battery and lasts for about 8 hours with careful use at a cost of £1.89. (This radio refused to work on zinc-carbon PP3.)

The radio on the right has been converted to run on a single "C" size of alkaline-manganese cell and a Verkon V12 dc/dc converter. It gives about 6 hours duration, but at a cost of only 69p—a 50% saving. However, as we have just seen, single cells are suitable for recharging but PP3 batteries are not. The Verkon/single cell set-up will cost at least ten times less to run.

In a year's operation, this particular radio saved a total of over £20, more than it originally cost to buy.

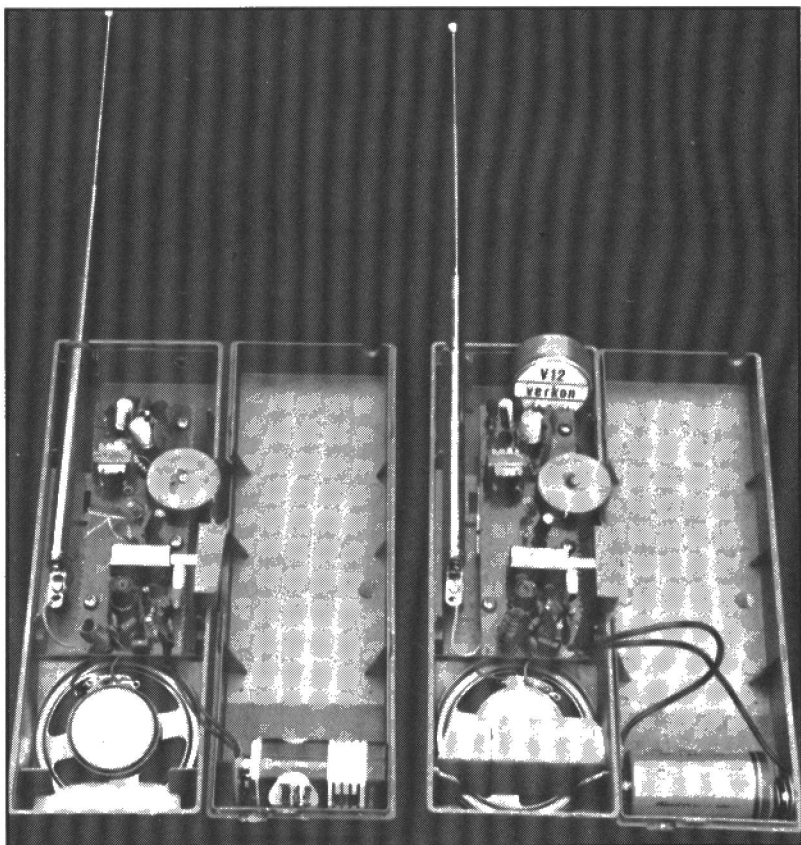


Photo 3. Practical case study—cheap CB operation

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MULTIFUNCTION COUNTER

PART 2 BY MIKE DELANEY

The counter takes shape build it—test it—use it!

THIS month, the final part of this project, deals with all the necessary details to build and get the counter working.

When first setting up, and *before* inserting any of the chips, it is necessary to test the trigger threshold of the overvoltage, 'crowbar', circuit, and this is done using an external bench supply in place of the mains supply of the circuit. The procedure will be fully explained later.

R105 and D101 are both mounted on the front panel. Had it not been necessary to blank the display in HF and 0-01 mode then these components would not have been necessary, the meter's own display would have been indication enough of power-up. Again, the brightness of the l.e.d. can be adjusted to your own taste by changing the value of the resistor. In amongst the line-up of i.c.s on the circuit diagram is C20, a 10 μ tant. This is important as it decouples the supply to the TTL chips.

Connections between the two boards are conveniently positioned, and in the prototype push-on connectors were used, though this was mainly for convenience. The edge connections are numbered and lettered. The system used should leave no doubt as to whether it's a real, or a hook-up fault. A1 goes to A1, and so on.

On the circuit diagram these connections appear in boxes. At first it may appear a little confusing as to which 'D' is which, but a little thought will soon make it clear.

CONSTRUCTION

Figs. 5 and 6 show how the p.c.b.s should look when completed, refer to them while mounting the components.

It is very easy to solder a component in wrongly, but a different job to remove it! *A quick double-check is a good idea.*

If you do not have the p.c.b.s plated-through, that is, all the holes have a covering of tracking running through them, then you have a bit more work to do at this stage. Starting with the smaller board, determine which is the front—it's printed on, bottom left.

Locate and solder in R105 first. This is the only resistor mounted on this side.

There are quite a lot of stitch-throughs needed on this board. I think the easiest way of deciding which is a component hole, and which is a stitch, is to mount all the components first. If this is the way you wish to work, then now is the time to mount the displays. These are easy to locate. The danger is that you will get one upside-down. If this should happen I would suggest writing off the display by cutting the legs off it and removing these one at a time. It seems expensive, but it's cheaper than a new p.c.b.!

Before soldering the displays in place have a quick squint along them, lining them up soldier-fashion, just to make the display look that bit better when it's done. Having done the display, now position the switches. Be careful to make sure that you have the momentary switch, S104, in the right place, and the right way up, that is in the off position with its lever in the up position. Double check and line them up again before soldering. Do not solder in D101 yet, since its finished position is dependent upon the spacing between the p.c.b and the fascia panel.

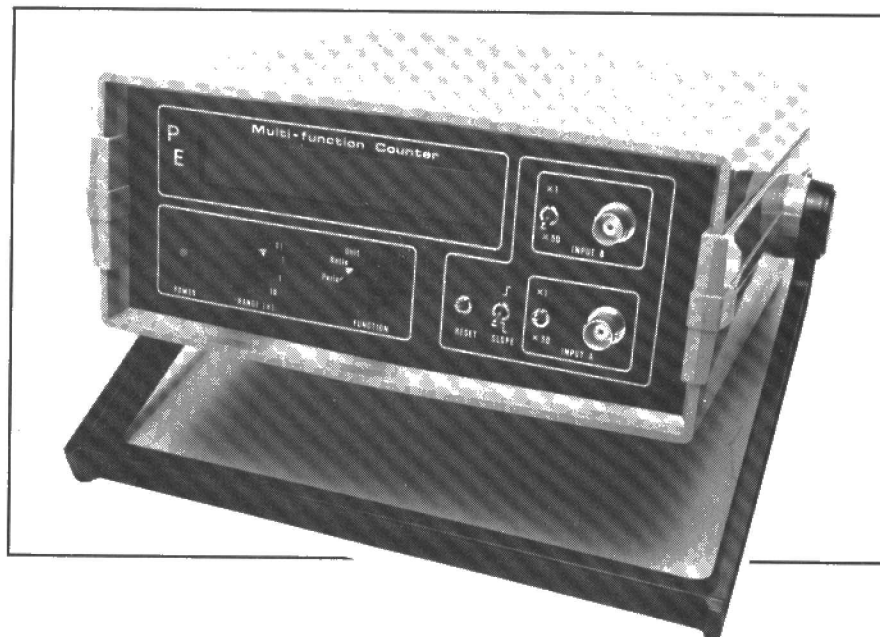
Turn the board over and mount the turret tags, resistors and capacitor, push-on connectors, and S105 and 106. This should leave only the stitch-

NOTE: This project is a 200MHz counter, not 20MHz as indicated on the cover of the June issue

through's and the l.e.d. to go. Solder in the stitch-throughs and carefully check the board. Connections to the switches are all made from the display board. Studying the layout drawing will help, but again, 1 goes to 1, A to A and so on. Now on to the counter board.

Once again, get it right way up and proceed in the same way as you've just done with the display. Use sockets for all the i.c.s except the prescaler. In my prototype I found that a socket appeared to increase noise pick-up and, of course, sockets are not a good idea with high frequencies.

Start with the diodes, then the resistors, and slowly build up the height of the board. The last soldered component to fit is the mains transformer. *Do not fit any i.c.s yet*, and don't bother with the FS2 either. Note also that some of the components must be soldered on both sides. This is most important if yours is a non-plated-through p.c.b. These have also been marked, so should offer no great problem. Having completed this, check for errors, eg, caps reversed, missing stitch-throughs, components soldered on both sides when necessary, and so on.



MULTIFUNCTION COUNTER

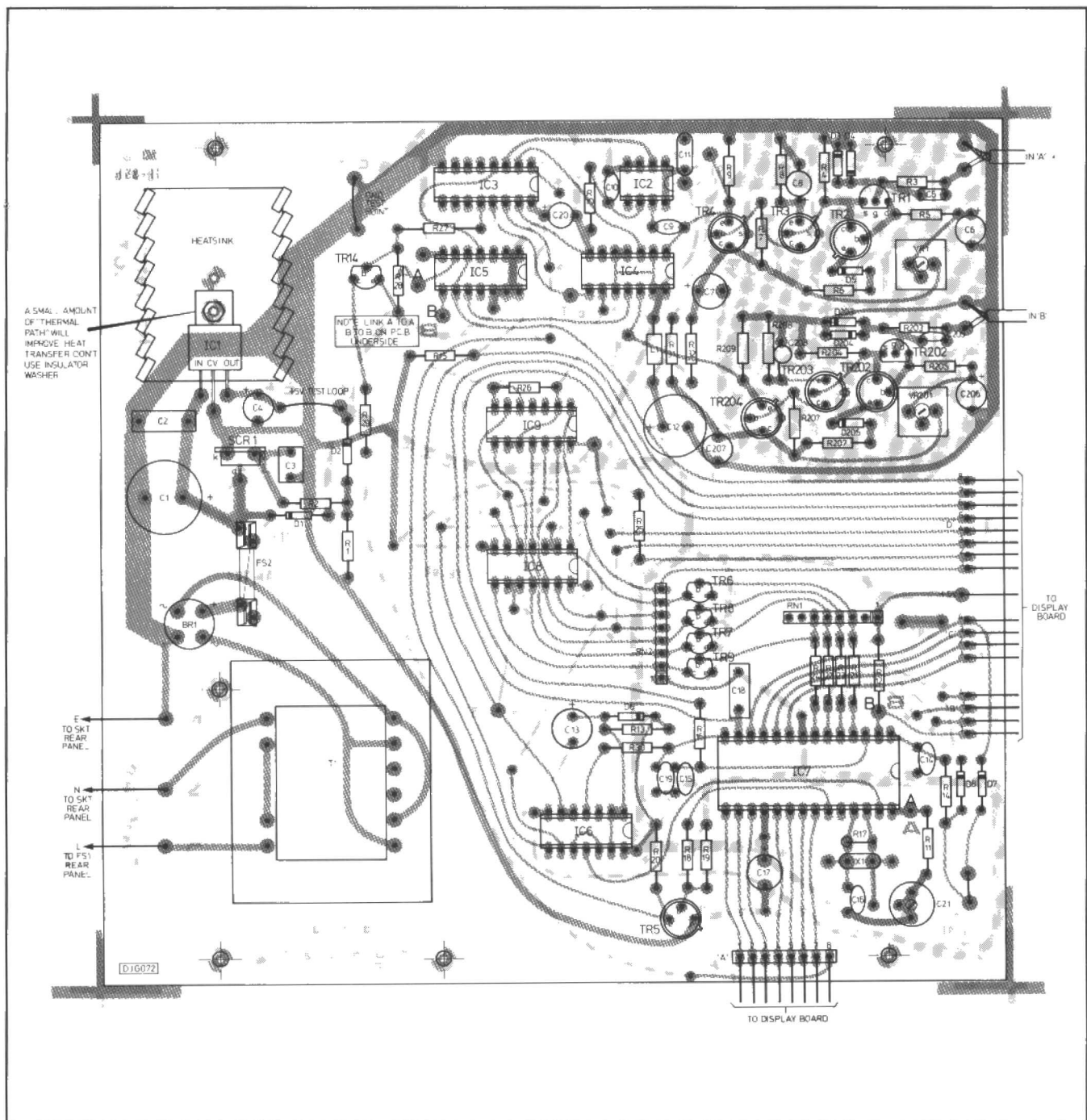


Fig. 5. Main circuit p.c.b. layout (less than actual size)

Lastly, solder the two screened links on the underside of the counter board from IC5 to the counter chip. Earth only one end (IC5 end) of the screen and use sleeving to prevent the screen shorting. Keep the links short and neat and if necessary crop any sharp component leads to prevent chafing the insulation. Resistor networks (R33-R39 and R40-R46) are worth a mention at this point. They consist of an array of resistors, seven in all, each of which has one leg available to the outside world and the other is commoned off internally, giving eight legs in all. The common leg is identified by either a dot or a mark moulded in one end. This is pin 1. Make sure to

identify this correctly before fitting these devices as they are not easy to remove from a p.c.b. and the faults they can cause when inserted wrongly are sometimes pretty obscure!

If you are satisfied that the two boards are correct, put them on one side and assemble the front and back panels. Take care to make sure the mains cabling is correct. Offer up the display p.c.b. to the fascia, check the alignment of the displays and switches, and position D101. By allowing the legs of the l.e.d. to move back and forth in its mounting holes it is possible to get the length for the legs easily. Having ascertained this, solder them in from the back of the p.c.b. and trim off

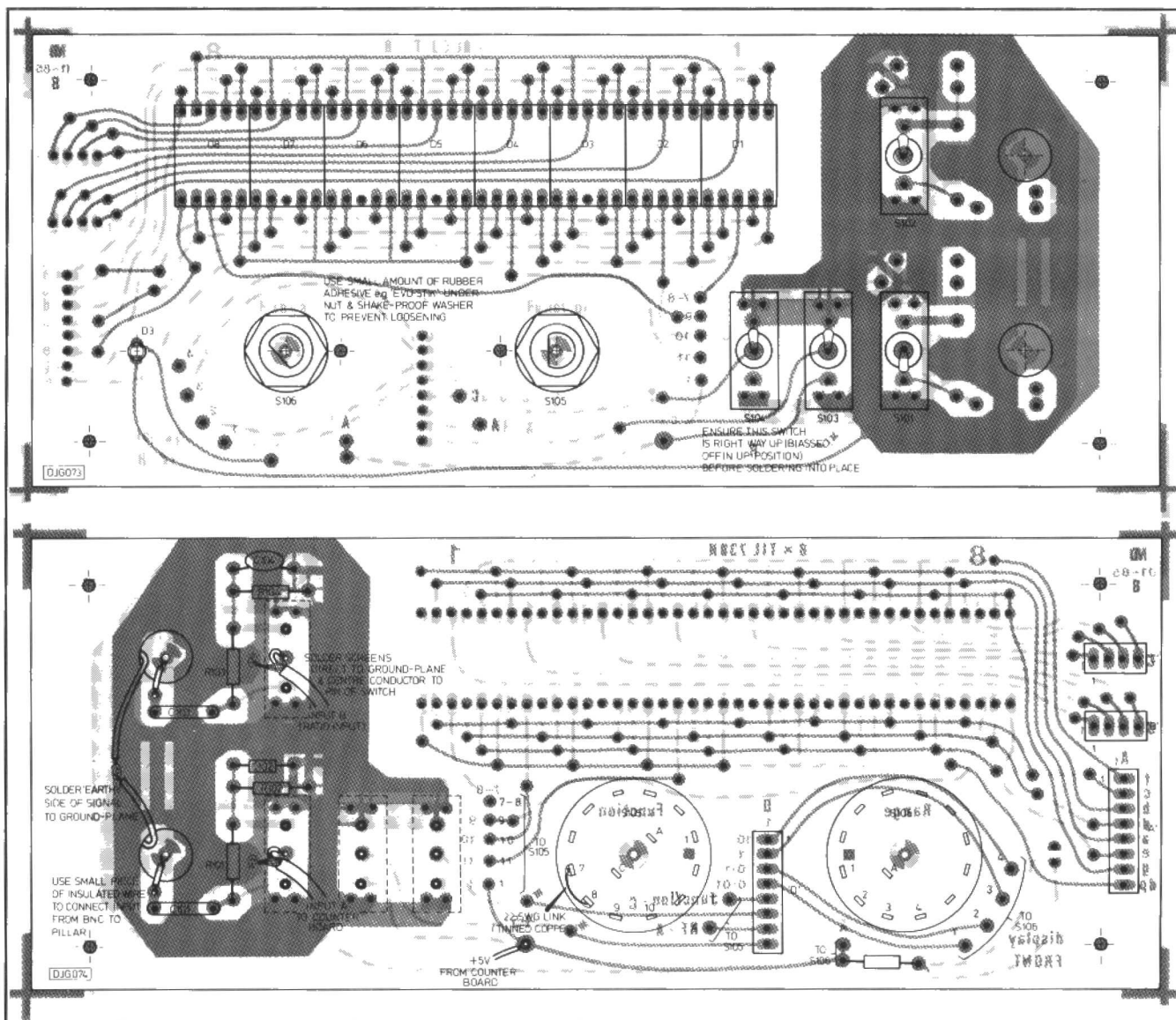
the waste. Don't connect the two p.c.b.s yet, some tests need to be carried out first.

INITIAL TESTING

These tests must be carried out before any of the i.c.s are fitted to the board. This includes the regulator or this may be damaged. Put a temporary link on the underside of the board, using insulated wire, from the IN to the OUT holes of the regulator, thus bypassing the position where it will later be fitted. The test equipment you will require to carry out this first test is:

1. Variable d.c. power supply, current limited at about 200mA. It must be protected against short-circuit

MULTIFUNCTION COUNTER



MULTIFUNCTION COUNTER

current consumption should show a steady flow of about 250mA. Disconnect and reconnect the supply and check that all digits come and go together and one or two do not show a tendency to surge in their brightness. If this occurs, the probable cause is the master oscillator and will need sorting out before proceeding. If all appears well, disconnect the PSU and carefully cut and bend apart the TP 4 loop. Reconnect the supply and check the display as before, but now change the range and confirm this is working. *Do not forget that in HF-01 the display should be completely blanked.*

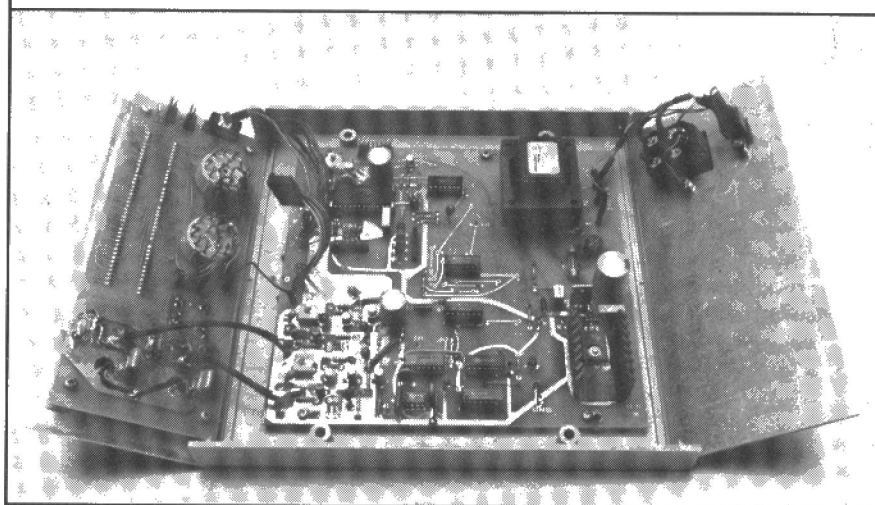
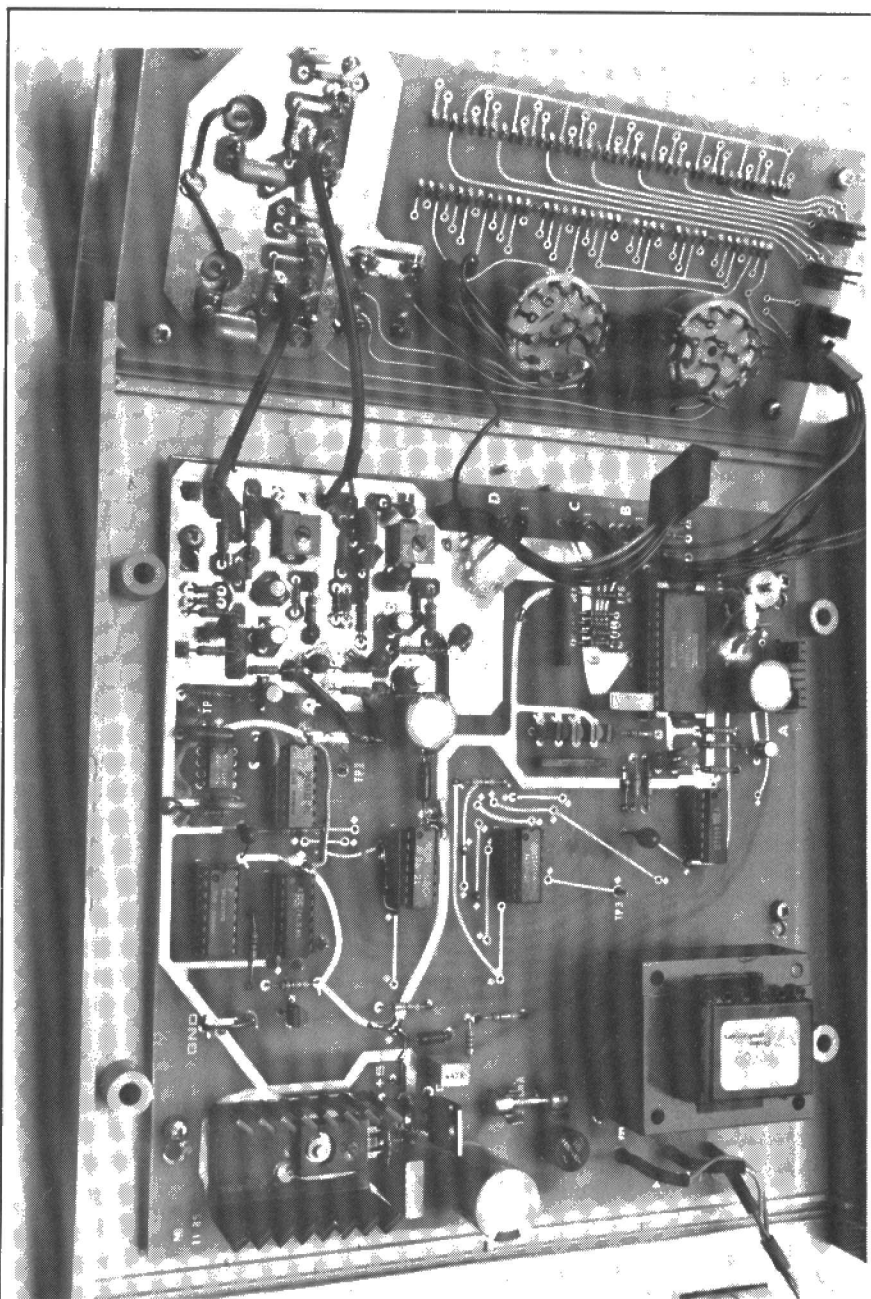
Recheck the current. With three zeros lit the consumption should be in the region of 130mA. If it should differ by any large amount check for overheating components first, then remove the power and give both boards a close visual check. So far you have determined the counter, display, switches with their associated logic, and wiring between the two boards is okay. All that's left to test are the two input amplifiers.

On the display board connect the input side of C101 and C102 to 0V with short lengths of insulated wire. Connect the meter between 0V and TP1. Set it to 10V d.c. Connect the PSU and monitor the voltage on TP1 while adjusting VR1 gently from end to end. The voltage should swing between -5V and 4V. Set to 1-5V to start with, and if you have a 'scope, check the amount of noise present on TP1. This should be less than 10mV of high frequency, and about this much low frequency. Any more than this will effect triggering on low amplitude signals.

Repeat this with Amp B, this time adjusting VR201. This establishes that the d.c. coupling in the amps is correct, and sets it to be near the switching threshold of IC4a and IC4b.

To set the amps to optimum sensitivity a sine wave audio generator will be needed. Remove the shorts from the display board and make a temporary connection to the BNC sockets. Remove the meter and set the generator to 1KHz at 100mV RMS. Deselect the attenuator (X1), and select LF & 1 Sec gate time. Trigger selection does not matter at this stage. Connect the generator to input A, and carefully adjust VR1 until the display shows 1-000, and is stable. Try rocking the pot back and forth to get the feel of the span. Now, by gradually reducing the input voltage and adjusting the pot it should be possible to get a stable display with as little as 20mV RMS input.

Having thus set for maximum sensitivity check that changing from positive to negative edge triggering does not alter the display. If it is found that the display changes at this stage, pro-



Photos illustrating the constructional details of the Multifunction Counter—a professional looking project, indeed!

vided it is only a few digits of shift then this is not too serious, but if one edge proves noisy, then it could equally be the generator causing the problem. Increase the frequency and make sure the display tracks it in both polarities.

Select $\cdot 1$ and $\cdot 01$ ranges in turn and check digit shift d.p.s and correct frequency. Lastly check the 10s range and make sure this reads more or less right (don't forget the master oscillator has still to be set up). The reason for leaving this range till last is that it takes so long between readings that it is like watching paint dry if you try to test on this range! Increase the output from the generator and select X50. Depending on how much voltage is present in this mode the counter may trigger. Don't be too upset if it can't quite make it though, mine won't either. HF cannot be checked yet, so select Period and 1s. With an input of 1KHz at 100mV RMS the display should read 1.000 (1.000ms). Again, change ranges and check the display each time.

Select Unit. This time the display should cycle up, the least significant figure will be a blur, but the higher decades should change in sequence. Increase the frequency and check the higher decades. If you have access to a 1MHz oscillator, connect this in place of the audio generator, and check the count into all the digits. When in overflow the decimal point on digit 8 (most sig.) should light, but this will not effect the counting sequence. Check Reset gives eight zeros.

Remove the PSU and short the two inputs together, so that both will be measuring the same signal. Turn Function switch to Ratio, attenuators off, and Range to 10s. Power up, and check display reads $\cdot 000$. Set generator to 1KHz at 100mV RMS and connect it to the inputs. Do not touch VR1, but slowly adjust VR201 until a display of 1.000 is obtained. Once again, set the output of the generator lower and adjust the sensitivity until the best possible response is achieved. This completes setting up Amp B.

Checking the HF section is a more difficult problem. The main complication is the requirements of the prescaler, which cannot handle sine waves of less than 10MHz. So it is necessary to look for an oscillator which will satisfy this. The author used a CB radio, suitably dummy-loaded and tapped, and this worked fine. There is no reason why some other type of transmitter should not be used, but if you wish to use a CB (Fig. 7) then the frequencies ought to be on channel 1 (27.60125MHz). Channel 40 is 27.99125MHz, with a channel spacing of 10KHz. Select HF/1s, and check that the display is about right. Of course, it must be a good working set, not one which has been 'doctored'.

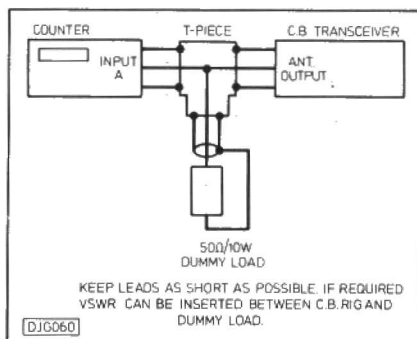


Fig. 7. CB test connections

Check the other ranges, paying particular attention to the dp position on each. When in the $\cdot 01$ range the display must blank completely. This completes Amp A and B tests.

MASTER OSCILLATOR

Only one more set-up procedure remains, that is the Master Oscillator, and is unfortunately the most difficult of all. The problem is how to set the frequency when you do not have access to an off-air or similar quality standard oscillator. This is the 'chicken or the egg' problem in this project. Using a good quality RF generator is one possibility (the CB rig again). The colour crystal in a domestic TV set is 4.43361875MHz, but great care is needed by an experienced hand to actually delve into the workings of a CTV, *they can kill you!* The actual source I leave to your ingenuity, so assuming that a stable and accurately known frequency is to hand, carry on as follows.

Apply the power and select Frequency range and time as appropriate for the input. Allow the instrument about 10 minutes to warm up, this is long enough at this stage, since this is only a 'ball-park' check. Apply the test signal to input A and wait until the display settles. Carefully and slowly adjust TC1 until the display is correct. It will

be easier to do this with the instrument in the 1s range, or faster as the 10s changes so slowly. From this quick check it should be clear whether or not the counter oscillator will trim in. If it will not quite make it, due to spreads in the value of the caps in the oscillator circuit, try changing the value of C16. Increasing it to, say, 56p will increase the display from 1000.0005 (1MHz) in the 10s range, to 1000.0250. At last, this all but completes the setting up. If all has gone well then it only remains to mount the counter into its case, connect front and back panels, and insert both fuses without mixing them up.

Before connecting the mains, put the meter on the 0V loop, and to either end of the fuse on the counter board. Make sure the leads are secure, then put one hand in your pocket before plugging in the mains. Check the voltage at this point is approximately 12V d.c. Leave the counter running for about 5 minutes, then switch off and **REMOVE THE MAINS PLUG**. Then check to make sure the rectifier has not overheated. I cannot overstress the importance of being very careful while you are doing this... **DON'T** take any risk with the mains. **It WILL kill you!** Now for the last quick tweak! Loosely put the case together, so you can have easy access to the oscillator trimmer cap TC1. Switch on and leave the counter for 10 minutes to settle down. Input your reference oscillator again, and with great care tweak the trimmer to get the correct reading. Leave the counter on, with its case together for about 30 mins, then check again. Hopefully the difference will be less than a digit. This has proved to be the case with the author's prototype when used with an Advance OFS 2 B off-air standard. Now the only things left to do are to bolt it together, and learn how to use it! I wish you luck, and much pleasure! If, however, you've got some problems, the next section should help you to sort them out.

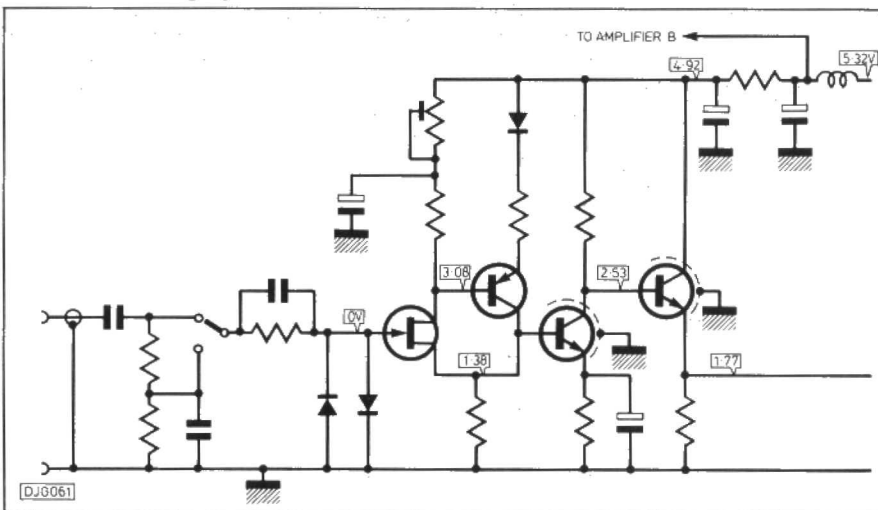


Fig. 8. Fault finding guide

FAULT FINDING

Do not attempt any tests with the unit connected to the mains if you can avoid it. The test equipment you will need to carry out these tests is as follows:

1. Bench power supply, giving 15V at 250mA.
2. A d.c. meter with a 1V and 10V range, and an input impedance of at least 20,000 ohms/V.
3. Utopia, or a 'scope. Whichever is easier!

But before you start rushing around measuring every node you can lay your hands on, sit down and list out the symptoms. Try changing the positions of all the switches one at a time, observing and recording as you go. Half an hour spent looking closely at your assembling is time well spent. To help with finding faults on the input amps, Fig. 8 shows some typical readings around the semiconductors, but treat these as a guide only. The results you see should be in the 'Ball Park' area. In all the tests connect the PSU as you did for initial testing, and remove FS2. If your problem is that nothing is happening at all, and even the l.e.d. on the front panel is out, check the supply coming out of the regulator. This must lie between 4.75 and 5.25V, and should be stable. The regulator circuit can be isolated from the rest of the circuit by cutting the 5V loop. If doing this allows the voltage to rise to 5V, then suspect a short on one of the boards. The boards should be separated to find which one is faulty. If it becomes necessary to take a knife to the track I suggest the easiest place for the 'First Incision' might be adjacent to R25.

Obvious causes of high current consumption are i.c.s in wrongly, short circuit tantalum caps, wrong polarity transistors and solder bridges, though not in that order. Having cleared this type of fault do not forget to repair any cut tracks, and then recheck the crowbar circuit.

It is very tempting in this kind of circuit, having a clever chip, that is the first bit to suspect. This leads to some 'headless chicken antics', often resulting in the device being damaged in any case. The price paid seems to have a direct bearing upon the degree of panic which ensues. So here are a few pointers.

The 7216B is probably okay if the display is showing any intelligible numbers. An oscillator fault should be suspected if only one, very bright digit is displayed. Due to the very high impedance of the oscillator the load of a 'scope probe is enough to stop it, so it's a go/no go situation. Component values are high on the list of suspects if the oscillator is faulty, so check them carefully. The only way the oscillator accuracy can be checked is with a known and stable input to the counter. If the display is showing some zeros then this tells you that not only is the 7216 probably okay, but so is quite a lot of the logic, plus the segment lines as well.

I have included TP6 especially to help with checking the DD and segment lines. Also the Function, Range and associated logic switches, along with the d.p. drive can be checked by using this point to trigger a dual-beam 'scope. Consider the 14016s as relays, with an input, common output and independent enable lines and you won't go far wrong. I have also included two TPs, 3 and 5, to help in signal tracing through the switches. To test the signal switching, first ensure that the input amps will set up correctly on TPs 1 and 2. You should see at least 3.5V swing (d.c.) on these when taking the pots from end to end.

After this, it is a fairly straightforward process to check and trace the signal and switch paths from the input amps to points A and B. This can be done with the d.c. meter, as long as you

d.c. couple the input by soldering a small piece of wire across C101 and C102. Connect the meter at 0V loop and point A or B, depending upon which amp you are checking. After that it is just a case of treating the whole lot as a logic process, and the highs and lows can be traced through manually by first applying +5V, and then 0V to the input.

If you should be tempted to try and feed signals directly into the 7216, note

that this must not exceed V + (5V) or go below 0V, or the counter will be damaged. As you can see from the circuit diagram, the TPs allow easy access to about 90% of the logic, sufficient to find any fault.

PI

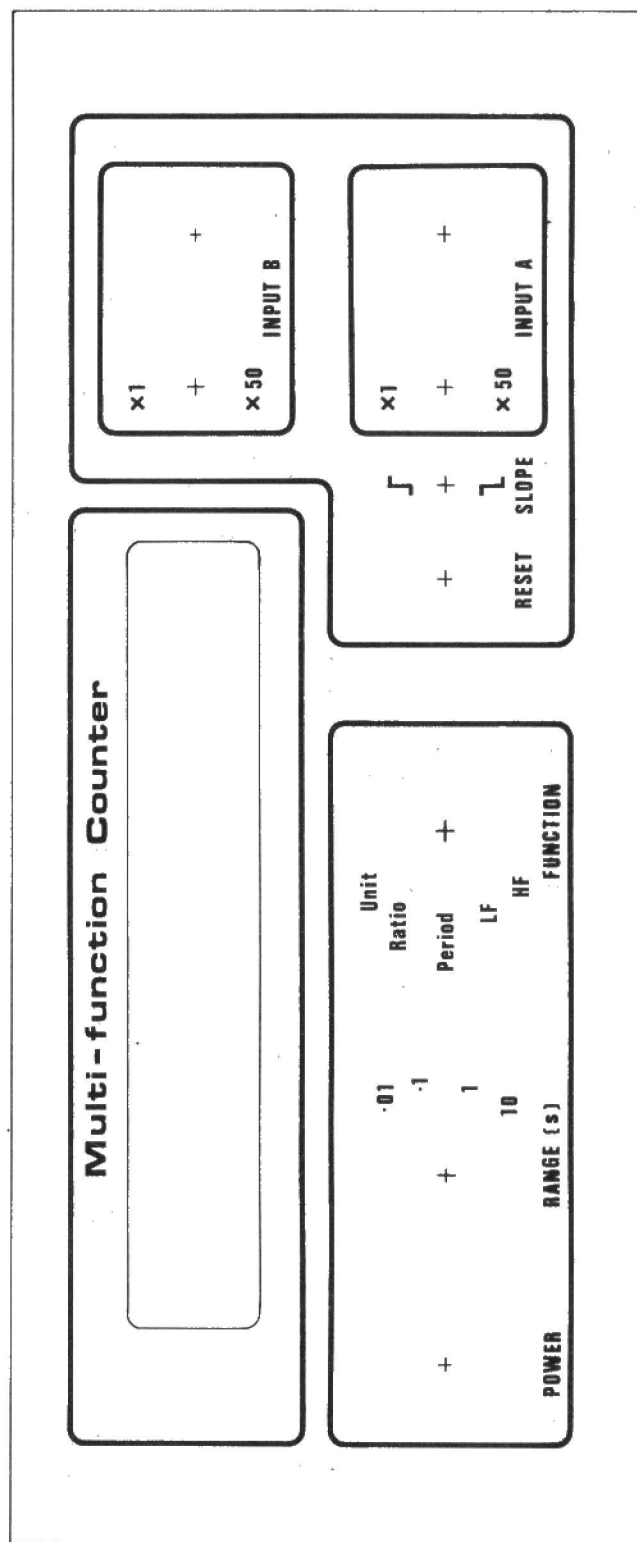


Fig. 9. Front panel marking details which may be used to produce a quality sticker or panel using a photographic process. A forthcoming feature in PE will describe this process in detail

ALTERNATIVE ROBOTICS

BY PROFESSOR JOHN BILLINGSLEY

Robot and Micromouse—the Cybernetic Challenge

CONTESTS such as Micromouse, Robot Ping-Pong and Build-a-Robot can be viewed as a lot of fun. They have to be enjoyable to persuade the contestants to put in so many months of creative effort. But they have a more serious side.

In the seven years since the announcement of Euromouse, great numbers of young (and not-so-young) engineers have come to grips with on-line computer control, sensor technology, stability theory and problem-solving algorithms. More important, they have succeeded in taking the essential elements of the theory and making them work in practice. Many of the entrants have no engineering qualifications, but engineers they are in spirit and achievement.

Robotics research is often fettered by the demands of industry. "You can't use this technique—it might not be cost effective. That one might upset the workforce." No such limitations apply to the enthusiasts, and they incorporate novelties in their mice sometimes years before industry sees them as valuable. Adaptation, learning and responsiveness to sensors are all essential to the Micromouse. Voice output was used several years ago; it enables the status of the mouse to be diagnosed.

Although Euromouse is a contest of speed, it can be taken gently. While exploring, the mouse can sit and think for a while without imperilling its score for its fastest run. That is not true of Robat—the robot ping-pong contest. Here a moment's hesitation will miss the ball and lose a point. The level of vision coordination which Robat demands goes far beyond any industrial robotic task. But is it beyond the bounds of reason for robots to lob components to each other? A bricklaying robot might well be kept supplied by hod-carrier with an accurate serve!

The then Director of the Science and Engineering Research Council's Robotics Initiative pronounced that games such as ping-pong were clearly beyond the possibilities of robot technology. The contestants are obviously not sophisticated enough to realise this; they seem likely to succeed.

THE HISTORY OF EUROMOUSE

Euromicro '80 was to take place in London, and the conference organisers felt that some lighthearted attraction would leaven the serious technical papers. An account appeared in the American IEEE Spectrum magazine of 'The Amazing Micromouse Maze Contest', with prizes for the fastest first run and the best learning run. The maze had a start in one corner and an exit target in another, and although a size constraint of fourteen feet was declared, the actual size and shape of the maze were not too clear from the announcement.

It seemed a good idea, all the same, and the European version of the contest was launched. Then the Spectrum accounts took on a sour note. A high speed 'dumb' wall-follower was outstripping all the brighter mice, and attempts were made to outlaw it—but was that really playing the game? Something was clearly wrong with the rules—after all, following the wall is the optimum strategy to reach the opposite corner of an unknown maze.

The answer was of course to put the target at the centre of the maze. The paths could be highly connected, and by surrounding the centre with closed routes the wall-followers could be baffled for ever. By declaring the maze dimensions (16 by 16 for binary convenience) and the coordinates of the target, the emphasis could be placed on control, navigation, mapping and strategy. The mice have certainly excelled in all of these.

Two months before the first London contest, a trial heat was held at the Open Day of Portsmouth Polytechnic. It taught everybody a lot. The first lesson was that mouse-builders are shy to show off their creations unless perfect. From two hundred applications, the number of contestants prepared to appear dwindled to two—and they were both Polytechnic students! Much pleading by telephone the night before the event brought the numbers up to just five.

Plessey's 'Fred' and Marconi's 'Meryl' were far from complete. Al-

though they were both impressive in terms of their construction and concept, one could only spin in circles while the other was good-humouredly driven by manual switches to entertain the sizeable audience. Algernon's guidance circuitry was crossed, so that it could only run straight into the first wall; one of the Portsmouth mice had processor problems and bounced about at random. Only 'Freewheelin' Franklin' made any real progress—and that was marred by a loose photocell connection. And yet the event was an enormous success. The audience seemed more delighted by the disasters of the mice than by their successes. Among the spectators was Nick Smith; he had left his mouse at home.

Also in the audience were five delegates from the Japan Science Foundation, who took the rules back to Tokyo and built up their own contest to great heights.

The next two months were well spent, and the European finals at Euromicro 80 were quite a different matter. Mice arrived from all over Europe, 'Midnight Sun' from Finland, 'Lami' from Switzerland, 'Superlite' from Germany and 'Yamahico II' from Japan. 'Fred' now took on a rodent shape, 'Meryl' was under full control and a new mouse 'Ancomical' was entered by ICL's amateur computer club. Technology ranged from 'Rainy Bricks', made from Lego, to 'Pascal', sawn down from a toy car and struggling to clear the corners with three-point turns. Lami was marvellously engineered with tyres made of cross-mounted micro-wheels. These allowed it to perform a virtuoso display of driving in a circle whilst pointing North. The novel wheels unfortunately demanded an absolutely flat surface, and an uneven joint in the maze-base marred Lami's contest performance.

One mouse was built around a CMOS processor. The body of aluminium had been carved out with tin-snips, and the wall-sensors were metal flaps which closed contacts salvaged from a relay. With no previous electronic experience, Nick Smith had put together 'Sterling Mouse', the first mouse to reach the centre and 'know' it



had succeeded. The strategy had its roots in Dynamic Programming, but was simple enough in essence that the calculations could be carried out as a delay routine between motor steps.

An Easter workshop was organised by the ICL computer club, where ideas were exchanged and advances were made. Thezeus and Thumper appeared at Wembley in 1981, founding a dynasty of winners. Thumper combined ingenuity with superb craftsmanship, with ingenious swivelling wheels which allowed it to manoeuvre without rotating. Thezeus established the practice of building a small personal computer into the micromouse—albeit with sawn-off keyboard. Fifteen mice took part in the Paris Euromicro finals, and Thumper became the new European champion. The rules had again been changed slightly, giving each mouse fifteen minutes in which to perform, the best run being counted. This put a premium on learning ability, and the time achieved for the best run had by now been cut to below a minute.

The 1982 British finals were held at the Computer Fair, Earls Court, the first of three such years. Two new 'Thezei' beat Thumper into third place, but all three times were below one minute. The University of Tampere in Finland played host to the 1982 European finals; they snatched victory from Thezeus-4 by a mere two second margin in forty seconds, and retained the title the next year in Madrid.

At last in Copenhagen, at Euromicro 1984, Britain won the title back in the shape of 'Enterprise', grandson of Thumper. The shortest path was seventy squares in length, covered in an amazing twenty-seven seconds. David Woodfield (Enterprise) and Alan Dibley (Thezeus-5) won travel prizes donated by the Japan Science Foundation

to join teams from Finland and Germany in the Japanese 'All World' contest in Tsukuba, held in August 1985.

Tsukuba was a spectacular event, preceded by a Japanese Final in which more than fifty mice vied for a chance at the world title. Further contestants arrived from South Korea and from the United States. No expense was spared, and the contest culminated in the presentation of yard-high trophies and huge cardboard cheques—with some pretty impressive figures on them. All the top honours went to Japanese mice, five out of six from the same Fukuyama club. Britain's Enterprise claimed seventh place, and the rest of the world trailed in the distance.

MOUSEATHON

A few months later a 'Mouseathon' was arranged in Boston, to help wake up America to what had been going on in the Micromouse world. Three British mice were imported, Enterprise, T6 and good old Thumper, to meet a visiting team from the Fukuyama club. Their mice were Noriko 1, Noriko 2, Noriko 3 and Noriko 4—quadruple honour to the name of their club president's wife. Based on the same chassis they carried varieties of motors, d.c. and stepper, and various extra sensors, such as home-made gyroscopes to help in cornering. When it came to the crunch Noriko 1 put up the best time, just half of that of the fastest British competitor.

I asked the winner a question, and obtained an answer which was hugely revealing of the Japanese approach. "Do you renumber your mice, so that the best is always Noriko 1?" "No, Noriko 1 is the oldest. It still has stepper motors. It is best because we have had longest to develop it!" So the technology of the winner was essentially that of the 'wheelchair' which had won the 1980 British final. But the refinements were fantastic.

ROBOT PING-PONG

In November 1981, a micro-robotics conference at Imperial College provoked the question "What can follow Micromouse when solving the maze is seen as easy?" Three-dimensional mazes were suggested, along with non-cartesian shapes and walls which move. All these are possibilities, although there are still plenty of challenges in the contest as it is. A contest of a different type was needed, and the solution was robot ping-pong. Playing very safe, I named a date five years off for the first heat—but it is all happening in four.

A group of entrants met in Portsmouth on 19th January, 1985, to exchange ideas and polish up the rules.

Three very primitive pieces of machinery arrived, two bat mechanisms and a vision system. Nothing really worked, although an oscilloscope trace showed a peak where the ball might just be. Less than two months later, the contest was introduced on BBC's 'Micro Live'. One of the mechanisms now leaped about, threatening mayhem to the presenter who stood too close. The vision system put up an excellent screen display of the track of a real bouncing ball, and a completely new arm succeeded in taking a swipe at the ball.

At the European Personal Robotics Congress in July 1985 the Robats did battle in earnest, although the best rally was just one hit. In Brussels that September they met again at the Euromicro Conference, and although the rallies were no better at least two of the machines showed consistency in tracking and hitting the ball when it was first served. One found its way to Strasbourg, to perform before the President of the European Parliament at the Europe 2000 exhibition. Not only did it defeat Murphy's law by hitting the ball perfectly, the ball rebounded from a wall, hit the spinning lenses of the novel vision system, and convinced the President that it had hit the ball twice!

The early Robats are erratic in their performance, to say the least. But from the first few tentative efforts, a whole new technique of dynamic robot interception is starting to emerge.

IN CONCLUSION

In Britain, Micromouse has grown up on a shoestring budget, begging space at annual British exhibitions and scrounging prizes from the exhibitors. It is none the worse for that. In Japan, however, there is a permanent Micromouse Secretariat. They were present at the 1984 Euromicro finals in Copenhagen, and awarded seven or more European participants free air flights to take part in the Japanese finals. The maze used at the European Personal Robot Congress was flown in by the Japan Science Foundation, so that any incompatibilities could be sorted out before Tsukuba, and mazes have been sent to South Korea and the United States. Could the importance which the Japanese obviously give to such contests be linked with their industrial success, perhaps in chicken-and-egg fashion?

Micromouse, Robat and Build-a-Robot will continue to give qualified and unqualified engineers alike the opportunity to innovate. Their ideas may spin off into industrial applications, the contestants may themselves be recruited by marketers of new robotic products. In all events, they enhance the awareness and ability of each participating country to exploit the rushing tide of technology.

PE

PRACTICAL MICROMOUSE

BY A. DIBLEY

Q. Is a ZX-Robot a Cybernetic Sinclair?

IF YOU want a new challenge to exercise your mind and not damage the pocket too much, try to get a self contained mobile robot to the middle of a ten-foot square maze.

The task is to build a mechanism to travel through, and solve an unknown maze. The maze has 256 squares (16 x 16) with 18cm sides and 5cm high walls, 1-2cm thick. Floor is matt black, walls are gloss white with red tops. You have 15 minutes to perform. During this time the mouse can make up to ten runs, starting at a corner square with an outside wall to the left, aiming to reach one of the four middle squares which are the 'target'. No outside 'intelligence' or power supply is permitted. Manual assistance is penalised, but a mouse in trouble can be rescued and restarted at the start square. Each run from start to target is timed. Fastest run counts. No strategies like trails of bread-crumbs or 'blast through the walls in a bee-line for the middle' are permitted.

Here are some hints to help you over the first difficult steps, or give you some ideas for later stages. They are based on methods I have used with varying success in six different working mice and several trial-and-error dead-end developments. These techniques may be usable on any project that needs an interface between a micro and a mechanism. They are as simple as possible. All are economical in parts and build-time.

THE ON-BOARD COMPUTER

First, consider the electronic bits. I used Sinclair ZX80s on two mice, and ZX81s on three others. Some pundits said that ZXs seemed unsuitable, but I believe that opinion was based on a misunderstanding of the requirements. You will spend many more hours developing the mouse than competing with it, so a lot of consideration must be given to the requirements of that experimental period. This applies to many hobby projects of this kind. Most of the following points are valid for several other less common micros, so while you read, think of the hardware

that you know about which is lying around unused. Consider:

Cost. A second-hand ZX80 or ZX81 will not break the bank. And if you inadvertently destroy it, you can replace it cheaply.

Convenience of software preparation. You can start by using mainly BASIC with a small amount of machine-code to drive the output ports. Or use a separate 16K ZX81 system to write the code with an assembler, transferring it to the mouse via tape. (Hints. Always run machine-code in FAST mode. If you use a ZX80 on the mouse, install a ZX81 ROM to give it compatibility with the ZX81 development system.)

Convenience of software modification during development. The BASIC interpreter is an excellent on-board operating system, allowing you to examine or change storage with PEEKs and POKEs and useful display/alter routines in BASIC.

Size. The ZX80 and 81 are the smallest easily available processors. **Availability.** There are thousands of them around.

Power consumption. The whole mechanism can be run for around half-an-hour on a set of 500mAh nickel cadmium cells.

Program loading via the cassette interface is a bit tiresome, but once you have it sorted out it is not as bad as people say. Do not connect the EAR cable while SAVEing, and keep the cassette recorder away from the TV set. The final version of code can be burnt into a ROM and called with a couple of hand-entered statements, but this is hardly worth it, considering the likely working life of the mechanism during competitions, as each run lasts a maximum of 15 minutes.

The normal Sinclair 16K RAM-pack is cumbersome for mouse use. 2K of storage can be fitted to the ZX81 by removing the two 2114 chips and fitting a 24-pin socket to take a 6116. Remove link L1 and make link L2.

To fit 4K of RAM to a ZX81, begin as for 2K. Piggy-back two 6116 chips, commoning all pins but 18 and 20, which must be bent out sideways to allow them to be wired direct to the circuit shown in Fig. 1. It is possible to

get all code, maps and variables into 2K of RAM though 4K will hold useful on-board dump and formatted display utilities to assist in development.

Fig. 2 shows a simple output system expandable to 8 bits, using TTL chips. Thezeus, the grandfather of my mouse-tribe, used only three output bits for all functions. (Note that I referred to the mouse as a man-mouse. The majority of successful mice have been male. I offer this as an observation only, and do not dare to make further comment on the matter.)

The circuitry between the 7474s and the output device depends on the load. A simple one-transistor driver stage will operate a small motor direct, but do not forget the reversed diode or other suitable suppression across any such inductive load. 7474s have an inverted output as well, which is very useful for driving more complicated output devices.

I glue the extra chips to the ZX board with the legs pointing upwards and make connections directly to the pins, to save weight, size and complications like plugs and sockets. There is not much space in most mouse chassis for luxuries like neat wiring systems.

The Z80 lines are soldered straight to the printed wiring on the Sinclair board. All the connections needed are available on the edge connector. There is no Micro-Mouse prize for elegance of circuit design.

All of the 74xx chips can be LS types or equivalent CMOS to save a little power. The 7474s can be piggy-backed like the 6116s, commoning all clock lines, all reset lines, and all voltage lines.

Use two power on-off switches, one for the processor, one for the output devices, motors, servos etc. Use a double throw switch for output power, the 'off' contact can be used to reset

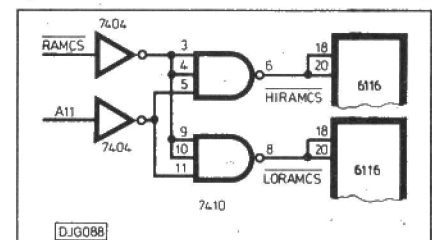


Fig. 1. ZX 4K RAM

the 7474s to prevent glitch problems during RAM-loading and preparation.

The ZX80 can be made smaller by cutting off the keyboard with a hacksaw and reconnecting the printed wiring with a plug and socket. The ZX81 can be removed from the case and the keyboard similarly connected. The board may still be too big to fit into the lower body of the mouse (depending on the way your design travels) and it must be carried above wall height but the importance of top-weight becomes significant only when the mouse reaches speeds of, say, 20 cm/sec or more. The keyboard is only needed when the mouse is not moving. To provide the start and stop functions necessary for control during a contest use a couple of small switches to act in place of the appropriate keys.

floor and the white walls. They all had problems which I did not want to solve and my philosophy was to use simple methods that I can make to work, but if you like them, use them.

Other hints are:

Read the input ports often enough to ensure that nothing important is missed. The sensor used to measure distance travelled must be read frequently enough to ensure that no pulses can slip between read commands. About one pulse per 2mm is frequent enough.

Pulse the infra-red emitters on for about a millisecond before you read the sensors. Some are very slow and the Sinclair circuitry seems to slow things more. Drive them as hard as you dare, to overcome the flood-lights at the competition site.

respectively FE, FD, FB, F7, EF, DF, BF, 7F from lower left clockwise. The A register will contain the input in the low-order 5 bits, with a 1-bit for unmade keys, and a 0-bit for closed keys.

Get a book about assembler programming for the ZXs.

THE ELECTRICS

Now consider the motor and steering systems.

DC motors. Can be cheap. Use simple transistor driver stages, which can be software-pulsed for speed control.

Stepper motors. More expensive and more complex to drive, but reduce the need for feedback systems. Fast, light, efficient steppers are expensive, but getting cheaper.

Radio-control servos, as used in model planes/boats/cars. Because they are driven by TTL style pulses in their natural environment, and powered by about 5V, they can easily be driven by pulses developed by a micro.

The pulses needed to drive most servos are positive-going, between about 0.8 and 2 milliseconds long, and repeated about every 20 milliseconds. Short pulses drive the servo to a point near one end of the travel, long pulses drive the servo to a point near the other end. Middling length drive pulses, about 1.2 or 1.5 milliseconds, put the servo at the mid-point. Different makes of R/C gear use different standards, but all are suitable, since the difference can be accommodated by software. Some have a gearbox which will allow the output to revolve continuously if the internal feedback potentiometer is replaced with a fixed external one. Then the output shaft can be driven in either direction as a drive motor and stopped by not providing any pulses. The speed can be varied by altering the rate at which the pulses are delivered, but the control is poor.

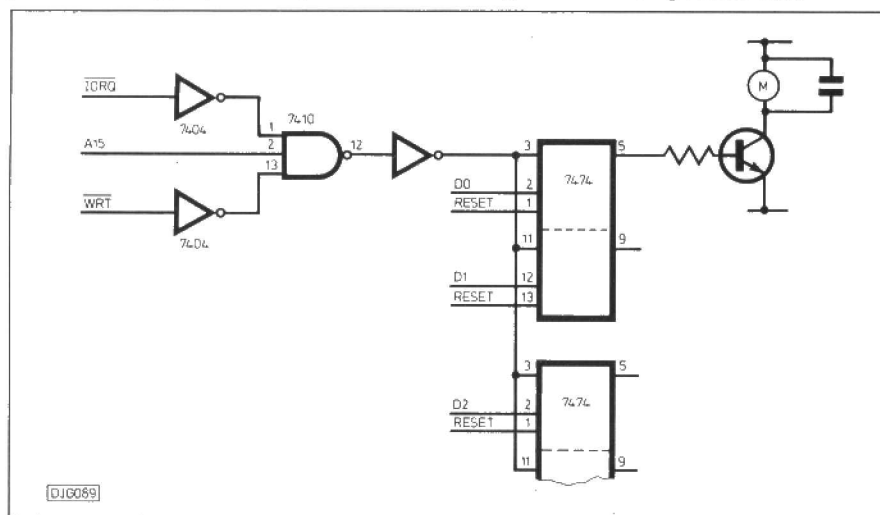


Fig. 2. Simple output system

SENSORS

Next to be considered are inputs. The ZX80 and 81 are provided with a 40-bit input system which is called a keyboard. Since it is there already, use this circuitry for sensor functions. The keyboard is arranged as 8 half-rows of five keys each. By connecting a switch between one-of-eight wires and one-of-five wires and using a short routine (now is the time to get familiar with Z80 assembler code) you have built a very economical sensor. It is necessary to make sure that none of the sensors are 'closed' when you need to use the keyboard in the normal way.

The only other types of sensors I have used successfully are infra-red, reflecting from the top of walls or from shiny segments on drive wheels, or with the beam interrupted by walls or a slotted disk. The maximum permitted horizontal dimension of 25cms allows sensor systems to overhang the walls.

Other builders have used sonar, infra-red reflected from the sides of walls, and a CCD camera to see the difference between the black maze

Use the circuit of Fig. 3 to amplify weak signals to operate the keyboard. Only used for reflected or long range systems. Any small-signal transistor will do the job. The diode provides a small fixed sensing threshold. a.c.-coupled circuits might be more effective to combat high levels of background infra-red.

Use a switch or micro-switch as a sensor if possible. Adjustments are easy if you can hear or see the sensor working.

It is unlikely that you will be using enough power to cause appreciable wheel-spin on the drive wheels, so the distance measuring emitter(s) may be fitted to the drive-wheel(s). The best tyre material is buff-coloured rubber bands (honestly), stuck with cyano-acrylate.

Use LD A,\$EF
IN A,0

for instance, to read the keys 6 to 0 (the top right half-row) into the A reg. The half-rows are addressed by the absence of one bit in the byte loaded to the A reg. That means that the addresses of the half-rows are

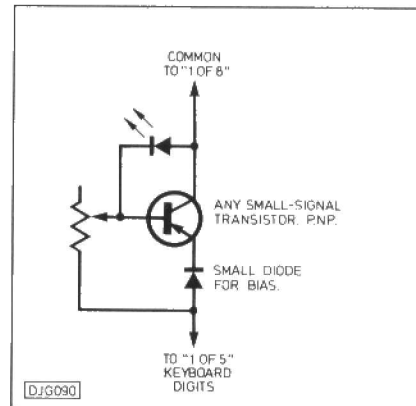


Fig. 3. Signal amplification

Whatever electrical bits you use, try to find ones that will work on the same supply as the micro. You do not need the complication of two sets of flat batteries 10 minutes before the competition starts. If your design is fussy about voltage, and goes 'off-tune' when the cells get a bit low you will need to fit a 7805 5V regulator fed by six cells. 500mA size cells will probably be big enough, since they only have to run for 15 minutes in the competition plus preparation- and waiting-time. Have some spares on charge, or make a voltage-sensitive charger that allows the battery to be topped up fast but safely. *If you use high-rate charging, use only vented cells.* If an overcharged unvented cell explodes it will damage the mouse and may cause injury.

THE CHASSIS

Before you can make much progress in the design, you must make the basic decision on the type of mechanism to build. Choose from:

Tricycle with one driven rear wheel. Steering two front wheels may be complicated if it will steer round corners as well as make corrections on straights. Thezeus is a tricycle mouse but uses a foot which lifts the whole mouse from the floor and revolves in multiples of 90 degrees to turn at corners or dead ends. This means that the steering has only to turn enough to make minor corrections in straight running.

Tricycle with one steering front wheel. It may be rear-wheel drive or front wheel drive. Rear drive needs a differential in the axle or two drive motors. Front drive might need the motor mounted on the steered part.

Wheelchair style, with one driven wheel each side, and idlers or skids front and rear for balance. Steering and turning is done by independent control of the drive motors.

'Thumper' style, named after one of the 'greats' of Micro-Mouse, this is one in which all wheels can be swivelled so that the mouse travels in any direction without turning the chassis. Thus the mouse travels north, east, south or west without rotating itself. This needs some better than average mechanical bits.

Any other mechanism which you think you can make to move under control. All the working mice which I have seen are of types 1 to 4, but there have been a few other designs which were not fully developed.

SOFTWARE

The software used will depend on the processor chosen. On the ZX80s I used hand-assembled code, entered

byte-by-byte, very patiently. It taught me Z80 coding as no other method could. On the ZX81s I used the Bug-Byte ZX81 assembler because there was not any choice at the time. It is a simplified but extraordinarily fast assembler with restrictions on label naming, and no advanced functions, but its simplicity is an advantage in some ways, and is not a limitation in software systems of the size of a mouse control program.

Later mice have software in EPROMs. I use a 48K Spectrum with the Ultraviolet Assembler (which assembles in COLOUR!) and a CAMEL BLOPROM-SP EPROM blower as a very economical but effective development system.

More important than the details of how to get the code on board is the necessity to understand the relationships between the functions that must be provided by the software. These are the main sections:

Draw a storage map of the walls discovered during running time.

From this information 'solve' the maze. That is, do the calculations for the next bit of code, which is the route-decision section, which instructs the motor and turning control to move to the next square.

While this is happening, keep track of distance moved and control the steering to keep it centred in the paths. *Do not underestimate the difficulty of making the thing travel in a straight line.* During this time the walls are being watched to keep a check on the accuracy of the distance measuring system and to provide input to part 1, so we have completed the software loop.

Error recovery. Scope for interesting fiddles here. For instance, to overcome the problems associated with the rule that no manual input is allowed between runs, it is possible to make the software detect the fact that the mouse has been lifted from the maze after a disaster.

Speeding up along previously explored straight runs. Deciding if and when the shortest route has been discovered, and confirm it by trying it. Then re-run it with the speed controls turned up faster, to try for a quicker time. There is nothing to lose.

Anything to amuse the audience —The best known mouse in the world is probably Dave Woodfield's Thumper. It talks to the audience and to itself while it is exploring the maze. A very difficult act to follow.

On the subject of amusing the audience, put a hairy mouse on board to give the mechanism a little crowd-appeal and make him photogenic. Even if it does not win, the mouse has his photograph in the reports, and is remembered and recognised.

When I started making mice I used the techniques I knew from building model aircraft and boats. The main structures were made from thin plywood, balsa and card. It can be drilled, sanded, carved, glued, pinned, screwed and thrown away if it is not quite right. No machine shop facilities are needed to make complex shapes. Even wheels were custom made by turning plywood discs on a small modeller's lathe, but an electric drill can be used instead. Bearings and steering mechanisms were made with brass tube, piano-wire, solder and pins. Epoxy and cyanoacrylate (super-glue) adhesives are wonderful for construction methods of that kind. It is also useful to be the sort of person who never throws away anything that looks as if it will be useful for something or other at some time in the future.

... AND WHEN THAT ONE WORKS

Mice based on ZXs are limited in their maximum performance by weight and power consumption. To build a world class mouse needs time and money invested in specially designed CMOS based controllers. It will probably have D-A and A-D converters to drive the servo systems. It will use high performance rare earth-magnet steppers or coreless armature d.c. servo motors. It will cost much more than the cheap and cheerful devices described here, in cash and time. And it will not give as much satisfaction in its building as a ZX-based machine. That is my excuse for abandoning the chase for ever more speed, because once you have mastered the art (I think it is an art) of getting a mouse to the centre target with reasonable reliability, you will want to make a faster one, then a still faster one, then ... You have been warned. **PE**

THE CHALLENGE

The object of this article has been to encourage more entries to the Micro-Mouse contests. There are hundreds of computer clubs and school electronic groups who might like to focus the expertise of members on a new challenge. Is there a group in your area that might be encouraged with some sponsorship? Will we see new games on the leader board at the next Championships? There is a competition class for previously unplaced entries, so don't worry about competing against the old hands. Rules and entry details are obtainable from the I.E.E. Computer and Control Section at Savoy Place. AND ENTRY IS FREE ... what an irresistible bargain.

ROBOTICS REVIEW

BY NIGEL CLARKE

Micros and robots— the stuff that dreams are made of

MANY makers of small robots have harboured dreams of repeating the successes of the early days of the home computer boom and of developing the machine which brought robotics into the home and made fortunes for the people involved. They would become the Sir Clive Sinclair of the robot world but without making the same mistakes as the market matured and sales fell.

In the early days the dream was no doubt fostered by the close relationship with home computers. Most machines were controlled by micros so if the product was right and the price low enough sales would take off.

Unfortunately the dreams did not become reality. Despite the undoubted interest in robots both fictional and factual they have failed to achieve the large sales which were hoped for. They have tended to split into two separate areas, toys and educational. Some of the toys, particularly in the Tomy range, have been quite sophisticated with a certain amount of memory for routines but others have been little more than plastic models like the best-selling Transformers.

Any robot which was capable of anything more serious, be it an arm or a buggy, controlled by either a dedicated controller or by a micro, was considered too complex just to be taken home and played around with. The middle ground remained open for exploitation.

The problem for anyone wishing to occupy that middle ground was that if the home computer pattern was to be followed then playing games would have to be catered for. While fine in theory the practice has been slower in being achieved.

Because of their price and software orientation, buggies have been seen as the most likely robots with which to play games. And now InterGalactic Robots of London, a company which has long promoted games—playing robots, is hoping to be able to announce a specially-written game for its Zero buggy.

Details are limited but it is being described as a robot video game with control and scoreboard on the screen and Zero playing the game on a table.

The first version is being written for the Commodore 64.

Another manufacturer looking to break out of the educational market is Clwyd Technics with its school-designed Trekker. The possibility of selling through retail outlets in the High Street is being considered and to increase its appeal a talking version is being developed. A prototype is already completed with production now being looked at.

In the meantime both manufacturers are hoping to build on the success of their machines throughout the world. In common with a number of other robot manufacturers they are finding a ready market in many countries in Europe as well as the US and Australasia. And IGR is now having talks with the Chinese government to set up a deal to introduce Zero into their schools.

COMMUNIST ROBOT

During the last three months the company has received enquiries from a number of socialist countries and the Chinese deal appears to be going well. It is expected that the agreement will be for Zeros to be made in China under licence with as many of the components as possible being made there.

IGR is also adding to Zero's facilities by the provision of a remote control system. It will be radio rather than infra-red and is expected to be ready by the end of June.

The makers of Trekker are expanding its possible market by developing a version which will work on three of the Commodore machines, C128, C64 and Vic. At present it is only available for the BBC B.

They have also been asked to prepare a Danish version using Comal.

All the developments are keeping the children of the school in North Wales, where Trekker was first made, very busy. Alex Whittaker, the teacher in charge of the project, said the response since the launch last year had been very good and it was now on sale in 14 countries. The only problem was in persuading people that Trekker was all they needed, instead of the usual extras, to enable the buggy to be linked to the BBC.

One buggy which will not be following in the footsteps of Zero and Trekker, at least not for a while, is the one which had been planned by Memoco Electron of Leicestershire. The company has been involved in other electronic projects away from robotics since the beginning of the year and work on the buggy has been suspended.

The Electron arm, however, is another of the British products doing well abroad. Bob French, the owner, said that large orders kept coming from all over the world for the arm, which is a programmable version of the Tomy Armatron.

To increase its capabilities a version of Logo is being written for it.

The Electron has five axes and a gripper, interfaces for C64, BBC B and Spectrum and can be controlled from a keyboard or by joystick. The company's achievement in adapting the arm has been recognised by its being given a Midland Industrial Design (Midas) award.

At Cybernetics Applications of Andover the ever-growing range has continued to expand with the addition of an expansion board which can provide an extra 16 inputs and 16 outputs. The prototype has been completed and a production model is expected soon with a price of about £120.

The board will allow extra sensors to be attached to the Cybernetic range and increases the number of arms which can be networked.

Cybernetic now has four arms, the hydraulically-powered Neptune and Naiad, the mechanical Mentor and the Serpent scara. In addition it has a work cell with conveyor and sorting table.

There have been further delays affecting two arms which had been expected to be launched last year.

L. W. Staines of Essex does not think the market is ready for its two-armed Troll robot. It is now intending to delay its announcement until September when it is bringing out a catalogue which will also include its Ogres.

HCCS of Gateshead is still trying to find a solution to the problem of designing a gripper which can be manufactured at a reasonable cost but also be robust enough to fit the rest of the machine.

PE

RS232 BREAKOUT BOX

BY JOHN LEWIS

Communication trouble? Give yourself a break!

TO THE uninitiated, serial communications between computers and peripherals appears to be a black art. RS232C, or V24 as it should more properly be called in Europe, is supposed to be a standard—but unfortunately there are so many different flavours that what should be a simple connection often turns out to be a mammoth undertaking. The professionals use a breakout box to link and cross switch the various combinations of connections but these boxes tend to be expensive and beyond the pocket of the person who only rarely needs to

join up a printer or modem to his computer.

The RS232 standard connector is a 25-way, D-type connector and has been specified for a wide range of asynchronous (unclocked) and synchronous (clocked) circuits between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE). These are jargon for Computers—DTE devices, and peripherals—DCE devices, such as modems and printers.

The full definition of the interface is given in Table 1 which looks highly complex and confusing. In fact most people will only ever use six or seven of the possible 25 connections, for printers; meaningful communication can be established with as few as three.

The most important ones are pins 1, 2, 3, 4, 5 and 7—Ground, Transmitted Data, Received Data, Request to Send, Clear to Send and Signal Ground. In some instances pin 20—Data Terminal Ready—may take the place of CTS. In some instances you may not need to connect both 1 and 7 since they are both earth lines and most likely are internally connected anyway. If you have a choice connect 1, since that's the screen over the cable which will prevent any interference from your signals affecting other equipment and vice versa.

The signals on all these lines are fairly self-explanatory. Received and transmitted data is as expected. Request to Send indicates that the DTE is ready to send data whilst CTS shows that the DCE is ready to receive it. DTR signifies that the terminal is ready and that the peripheral should be connected to the circuit; in some instances, for example with printers it is used to signal that the printer is ready and in these instances takes on the role of CTS.

HANDSHAKING

RTS, CTS and DTR perform the essential 'handshaking' between the various devices being connected together. The purpose of handshaking is to ensure that the data being sent from, say, the computer does not exceed the capacity of, say, a printer to receive it. Should the printer not be able to cope with the amount of data being sent the

computer needs to be told to stop sending until the printer has cleared the backlog. The way to do this is for the printer to turn off its acceptance of the CTS handshake. The computer then stops sending data until such time that CTS is turned on again by the printer. This way the peripheral can keep in step with the data being transmitted by the computer or DTE. Not all programs or machines use hard-wired handshakes, some use software implemented ones known as XON and XOFF. These are special control codes which are transmitted along the data transmission lines to control the sending of data in much the same way as RTS and CTS operate. Obviously if XON and XOFF are used you don't need RTS, CTS or DTR. Needless to say the two types of handshaking are not compatible so if you find that you seem to be losing data at a peripheral, check the handshaking employed by the computer, the application being run and the peripheral.

It should be easy to connect a computer to a modem since the convention for specifying these two devices is quite standard. The computer is a DTE whilst the modem is a DCE and the connections are straight through. Pin 1 from the computer goes to pin 1 on the modem, pin 2 to pin 2 and so on. The difficulty comes when you are not sure whether the peripheral is configured as a DTE or as a DCE, for example if you are trying to connect two computers together they are both DTE devices. So here it's necessary for the Transmit data terminal from one to be joined to the Receive data terminal on the other, and RTS on one to be joined to CTS on the other.

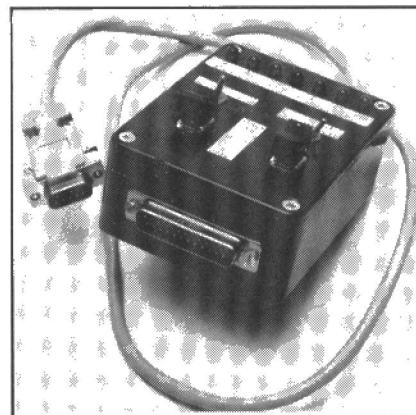


Table 1. RS232 pin specifications

PIN NO	FUNCTION	ABBREV
1	GROUND	FG
2	TRANSMITTED DATA	TXD
3	RECEIVED DATA	RXD
4	REQUEST TO SEND	RTS
5	CLEAR TO SEND	CTS
6	DATA SET READY	DSR
7	SIGNAL GROUND	SG
8	DATA CARRIER DETECT	DCD
9	POSITIVE TEST VOLTAGE	
10	NEGATIVE TEST VOLTAGE	
11	EQUALISER MODE	QM
12	SECONDARY CARRIER DETECT	SDCD
13	SECONDARY CLEAR TO SEND	SCTS
14	SECONDARY TRANSMITTED DATA	STD
15	TRANSMITTER CLOCK	TC
16	SECONDARY RECEIVED DATA	SRD
17	RECEIVER CLOCK	RC
18	UNASSIGNED	
19	SECONDARY REQUEST TO SEND	SRTS
20	DATA TERMINAL READY	DTR
21	SIGNAL QUALITY DETECT	SQ
22	RING INDICATOR	RI
23	DATA RATE SELECTOR	
24	EXTERNAL TRANSMITTER CLOCK	ETC
25	UNASSIGNED	

RS232 BREAKOUT BOX

Just this sort of problem arose when I was trying to transfer text files from a BBC B micro to my Macintosh. Not having a breakout box I improvised initially with an old S-DEC board and wire jumpers which worked but wasn't a permanent solution. Not wishing to go to the expense of buying a breakout box I built one out of odds and ends from my scrap box. The presumption made was that I knew the configuration for my permanent micro—the Macintosh—so didn't need to do any fancy switching on that side of the circuit. It was the input side which was unknown and so any indicators and switches only needed to operate there. The circuit for the solution is given in Fig. 1. It allows you to interchange TXD and RXD and also RTS and CTS. In those cases where DTR is used this can be switched in place of CTS. When testing input signals, or to overcome the use of XON/XOFF, it is useful to be able to fool the other micro that it is getting the right handshaking signals. This is achieved by linking RTS and CTS on the input side. To monitor the status of various input lines, l.e.d.s are provided. In addition to the signals already mentioned it can be useful to see if carrier detect (DCD) and data set ready (DSR) are in use. These are usually only found on modems and are used to inform the DTE that a carrier signal is present and that the modem itself is operational.

CONSTRUCTION AND USE

Building this simplified breakout box should cause no problems. The main switches are of the changeover, centre off type, the others are just changeovers. I used rocker type switches for the two main ones but toggle ones are just as acceptable. There is nothing special about the l.e.d.s or resistors either. I hardwired the connection to the Mac into the box and used a 25-way D-connector for the input. You can if you wish hardwire the input side into the box—whether you put a male or female connector on its end is up to you since there is no convention as to what should be on the back of any piece of equipment. (For those of you who did not do biology at school a male connector is the one with pins sticking out.) In any case a gender changer will be a necessity to cope with the situations not covered by the connector you have fitted. (Again in case you didn't know a gender changer allows a male connector to be connected to another male connector or a female connector to a female connector.) If you intend doing a lot of RS232 link-ups it could be worthwhile investing in a length of 25-way ribbon cable which has male and female connectors on both ends.

Using the breakout box is simple, just fiddle with the switches until you get data being transmitted! However, if you wish to be more scientific there is a logical way to proceed. Let us suppose you are trying to get another computer to talk to yours. Firstly plug the output lead into the serial port of your own computer. Put the two main switches in the centre off position and switch in the RTS/CTS link to fool it into thinking that it is getting the right handshaking. Plug the free lead into the serial port on the other computer, using the gender changer if necessary. Load a text file on the other computer and print this to the serial port. You should see some of the l.e.d.s on the breakout box start to flash or come on. Now look at the Data l.e.d.s. If Data 1 l.e.d. is flashing then the data switch will need to be put in the cross over position, if Data 2 flashes then select straight through. If neither data light flashes then try switching the CTS/DTR switch to DTR. If the Handshake 1 l.e.d. is illuminated then select cross over on the Data switch; if Handshake 2 is on then use straight through. Cancel the Print command on the other computer, put the switches in the correct position; ready your host computer to accept data via the serial port and you can start printing the text file required.

COMPONENTS...

SWITCHES

S1, S2 double pole double throw (d.p.d.t.) centre off (2 off)
S3, S4 single pole double throw (s.p.d.t.) (2 off)

SEMICONDUCTORS

D1-D7 l.e.d. (7 off)

RESISTORS

R1-R8 1k $\frac{1}{4}$ W 5% (8 off)

MISCELLANEOUS

Multicore screened cable (9-way);
25-way D-type connector (2 off);
box, Veroboard, etc.

300 and 1200 for modem work and 9600 for communication with printers. If the baud rates of transmitter and receiver are not the same then garbled transmissions will result. The other parameters to watch are the number of data bits—usually 8 but may be seven—and the number of start and stop bits, usually 1 and 1 or 2 respectively. These can be altered when setting up your computer and you must ensure that they are the same on both sides of the link.

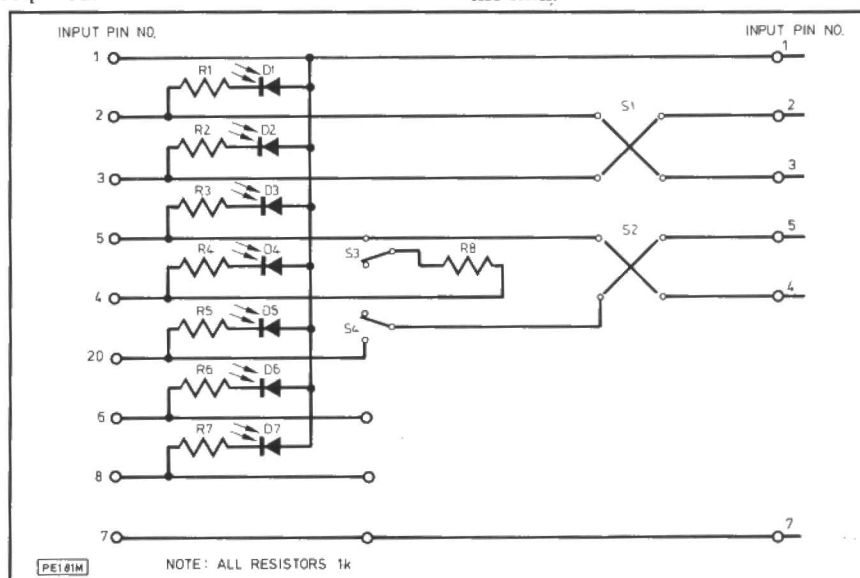


Fig. 1. Circuit diagram

In connecting to peripherals, the same technique is used except this time the DTR l.e.d. may be illuminated. The usual positions are cross over to connect computer to computer and computer to printer and straight through for modem work.

If after all this you still can't communicate or get garbage then you need to check the baud rate and data stream set-up. The baud rate is the speed at which data is transmitted—it can range from 75 baud (used in Prestel) to 19,200 baud. The common values are

There are variants on the RS232 interface such as the RS422. The main difference is in the voltage levels used. A true RS232 works on +12 and -12 volts whilst some of the others work on TTL voltages. In the majority of instances you can interconnect between them with no problems since the chips sets used today have been designed to have wide tolerance limits.

With the breakout box set up you should have trouble-free communication between your computer and anything designed for its serial port. **PE**

THE PE HOBBY BUS

PART THREE BY R. A. PENFOLD

Connection details and programs for the Spectrum, Amstrad, MTX, MSX and the Enterprise

ALTHOUGH the PE Hobby Bus project should connect successfully to virtually any computer which has the control, data, and address buses available, it is impossible to have a standard method of connection. Apart from differences in the type of microprocessor used in various computers, and consequent differences in the control bus structure, the available address range for input/output devices varies from one machine to another. Those who are experienced at interfacing projects to their computers can no doubt work out a suitable method of connection for themselves, but for those without the necessary experience, and those who have an unwillingness to risk experimenting with untried methods of connection, interfacing details for a number of popular home micros will be provided. We start here with connection details for several Z80 based machines. The computers covered are the Amstrad CPC464/664/6128, the Sinclair Spectrum, the Memotech MTX500/512, the Enterprise 64/128, and the MSX machines.

AMSTRAD CPC

The Amstrad CPC range of machines do not use the standard method of Z80 interfacing where only the eight least significant address lines and IORQ are utilized. A slightly different arrangement which involves some of the most significant address lines is used. With an unexpanded CPC464 it is possible to use a very simple method of interfacing where A10 and IORQ going low is used to activate the add-on device, with the lower address lines being available if a number of registers must be addressed. With machines that have disc drives and (or) the communications interface things are a little more stringent. In addition to A10 it is possible to decode A8 and A9 to give four pages of input output address range (&F8, &F9, &FA, and &FB). The eight least significant address lines must be decoded to place user add-ons at addresses in the range of &**E0 to &**FF.

There is no definitive way of connecting the Amstrad computers (or any others for that matter) to the Hobby Bus, but the suggested method is to use A0 to A4 as the lines which select the PIA and each of the seven slots, plus the four addresses within each slot. The address decoder responds to A5 to A7 going high while A10 and IORQ are low. Suggested basic connection details for the Amstrad machines (and the others) are provided in Table 1. Obviously other lines, such as the clock and interrupt types, can also be connected as suggested in the Hobby Bus circuit diagram. Initially though, it is probably best just to make the basic connections and to get the system up and running. Do not use a long connecting cable as this could result in stray coupling between adjacent cables, giving corrupted data or even crashing the computer. Half a metre or so is about the maximum acceptable length. It is assumed in Table 3.1 that the Hobby Bus is powered from its own mains power supply rather than from the computer. Therefore, no connection to the +5V output of the computer must be made. The current consumption of just the basic unit without any plug-in boards fitted would stretch the capabilities of most computers' power supplies, and the use of the board's own power supply is much to be preferred.

Connection to the 'floppy disc' port of the CPC464, or 'expansion' port of the CPC664/6128 is via a 2 by 25 way 0.1 inch pitch edge connector. As it is unlikely that a type fitted with a suitable polarising key will be obtainable, it is advisable to clearly mark the top edge of the connector as such. Connection details are provided in Fig. 3.1. Check and double check all connections very carefully, and if possible use multicoloured ribbon cable as this minimises the risk of muddling up any of the leads.

For the decoder to function properly the appropriate links must be fitted to the printed circuit board, and the eight d.i.p. switches must be given the correct settings. Details of the links and switch settings are given in Tables 3.2 and 3.3 respectively. In Table 3.2 a 'X' indicates that no link is needed, while '0V' means that the appropriate link terminal should be connected to the 0V rail. Suitable 0V connection points are provided near the link terminals.

MODIFICATION

With the suggested method of connection and the board unmodified, the RD input for the 8255 PIA is obtained by inverting the WR line using IC6c. With Z80 computers a RD line is available on the control bus, and it is

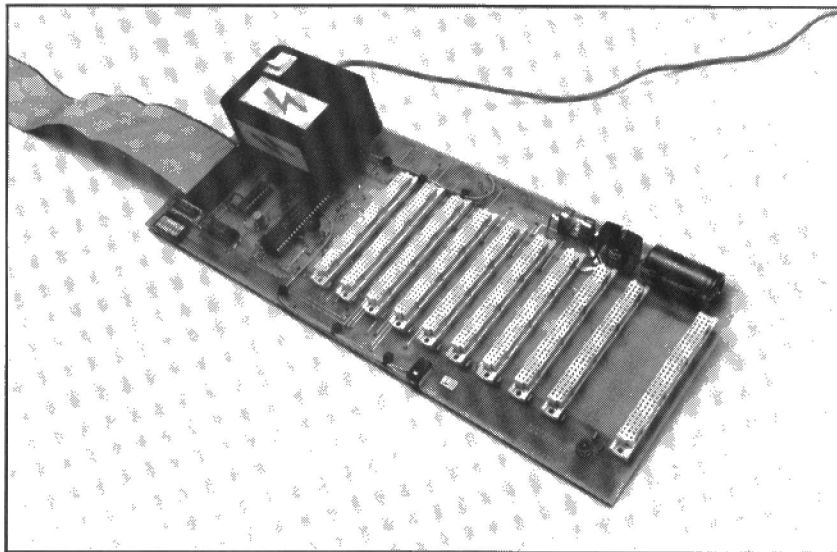


Table 3.1. Basic connection details for the computers

SK11 Pin Nos.	Amstrad	Spectrum	MTX	Enterprise
1	A4	A10	A4	A4
2	WR	WR	WR	WR
3	A0	A6	A0	A0
4	A3	A9	A3	A3
5	A1	A7	A1	A1
6	A2	A8	A2	A2
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17	A6		A5	
18	A7		A6	
19	A10	A5	A7	A7
20	IORQ	IORQ	IORQ	IORQ
21	A5			
22				
23				
24				
25	GND	GND	GND	GND
26				
27	D0	D0	D0	D0
28	D1	D1	D1	D1
29	D2	D2	D2	D2
30	D3	D3	D3	D3
31	D4	D4	D4	D4
32	D5	D5	D5	D5
33	D6	D6	D6	D6
34	D7	D7	D7	D7
35				
36				
37				
38				
39	RD	RD	RD	RD
40				

not necessary to generate one in this way. In practice the PIA seems to operate more reliably if the real $\overline{RD}$ signal is used in place of the synthesised one. To do this it is first necessary to disconnect the output of IC6c from pin 5 (the RD input) of IC7. This can most easily be achieved by omitting the through-pin situated roughly half way between link 5 and C16, or removing it if it has already been fitted. An insulated link wire is then fitted on the underside of the board from the point left vacant by the through-pin to pin 5 of IC4, being careful not to produce any accidental short circuits. It is recommended that this modification should be implemented when using the unit with any Z80 based computer.

Table 3.2. The links required for each computer

Link No.	Amstrad	Spectrum	MTX	Enterprise
1	X	0V	X	0V
2	X	0V	X	0V
3	X	X	X	X
4	X	X	X	X
5	0V	0V	0V	X
6	0V	0V	0V	X
7	0V	0V	0V	X
8	X	0V	0V	X
9	X	X	X	X

8255 PIA

There is insufficient space available here to permit a detailed explanation of how the 8255 is programmed to function in its various operating modes. However, in this context it will normally only be used in mode 0, which provides three eight bit ports (designated 'A', 'B', and 'C' by the chip manufacturer). Ports A and B can each be set as eight inputs or eight outputs. Port C can also be set as all inputs or all outputs, but it can also have split operation. This effectively divides it into two 4-bit (nibble) ports, with one nibble set as outputs and the other set as inputs. These are called port 'CL' (C Lower) and 'CU' (C Upper). Table 3.4 shows the number which must be written to the control register in order to set each of the sixteen mode 0 options. Table 3.5 gives the addresses of the four PIA registers, plus those of each slot. Note that as address lines A8 and A9 are not decoded, equivalent addresses in pages &F9, &FA, and &FB can also be used. In fact echoes appear at other addresses, but only addresses in these four Amstrad approved pages should be used when accessing the Hobby Bus.

TESTING

Connect the unit to the computer and switch it on prior to switching on the computer. The simple program shown below can be used for testing purposes. This sets port C for split operation, with the upper port set as outputs and the lower port set as inputs. This enables D2 to be controlled and S2 to be read. D2 should flash on and off, while the value printed on-screen should be either 0 or 4 depending on the setting of S2. The

program also provides output pulses on outputs 1 to 7 of IC8, and it should be possible to detect these with a logic probe or oscilloscope.

```

5 REM AMSTRAD TEST PROG
10 OUT &F8E3,147
20 OUT &F8E2,64
30 PRINT INP(&F8E2) AND 4
40 OUT &F8E4,0
50 OUT &F8E8,0
60 OUT &F8EC,0
70 OUT &F8F0,0
80 OUT &F8F4,0
90 OUT &F8F8,0
100 OUT &F8FC,0
110 OUT &F8E2,0
120 FOR D=1 TO 100:NEXT
130 GOTO 20
    
```

SPECTRUM

The Spectrum is another machine which uses a slightly non-standard method of Z80 input/output mapping. The basic idea is to take one of the least significant address lines low in order to activate input/output devices, and some of the most significant address lines are used if a device has more than one register. Address lines A0 to A4 are reserved for internal hardware or for Sinclair add-ons such as the Interface 1. However, all the other address lines are free for user add-ons.

The recommended method of interfacing is to use A5 and IORQ going low

Table 3.3. DIP switch settings for each computer

'S' No. Marked No.	Amstrad	Spectrum	MTX	Enterprise
S3 1	Closed	Closed	Closed	Closed
S4 2	Closed	Closed	Open	Closed
S5 3	Closed	Closed	Closed	Closed
S6 4	Open	Closed	Closed	Closed
S7 5	Open	Closed	Closed	Closed
S8 6	Closed	Closed	Closed	Closed
S9 7	Closed	Closed	Closed	Closed
S10 8	Open	Closed	Closed	Closed

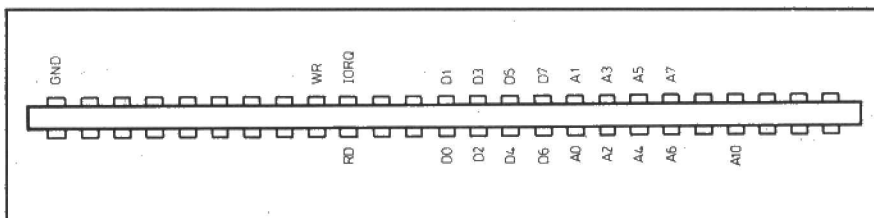


Fig. 3.1. CPC464 connection details

to activate the address decoder, and to have the PIA and slots selected using A6 to A10 inclusive. One consequence of the Spectrum's rather topsy-turvy address bus organisation is that, as can be seen from Table 3.5, the Hobby Bus does not reside at 32 contiguous addresses. Although at first sight the addresses may seem to be almost randomly scattered through the input/output map, they are in fact spaced 64 addresses apart. Fig. 3.2 gives connection details for the Spectrum's expansion port.

Table 3.4. The control number needed to set the 8255 in the various mode 0 options

Control Number	Port A	Port B	Port CC	Port CU
128	OUT	OUT	OUT	OUT
129	OUT	OUT	IN	OUT
136	OUT	OUT	OUT	IN
137	OUT	OUT	IN	IN
130	OUT	IN	OUT	OUT
131	OUT	IN	IN	OUT
138	OUT	IN	OUT	IN
139	OUT	IN	IN	IN
144	IN	OUT	OUT	OUT
145	IN	OUT	IN	OUT
152	IN	OUT	OUT	IN
153	IN	OUT	IN	IN
146	IN	IN	OUT	OUT
147	IN	IN	IN	OUT
154	IN	IN	OUT	IN
155	IN	IN	IN	IN

The program given below is suitable for testing purposes. It flashes D2 on and off, but there is no bitwise AND function in Sinclair BASIC it reads port A rather than S2. Taking PA7 to 0V should give readings of 127 or less—taking it to +5V should give readings of 128 or more. Pulses are provided at the outputs of IC8.

```

5 REM SPECTRUM TEST PROG
10 OUT 63711,147
20 OUT 63647,64
30 OUT 63775,0
40 OUT 64031,0
50 OUT 64287,0
60 OUT 64543,0
70 OUT 64799,0
80 OUT 65055,0
90 OUT 65311,0
100 PRINT IN 63519
110 OUT 63647,0
120 PAUSE 20
130 GO TO 20
    
```

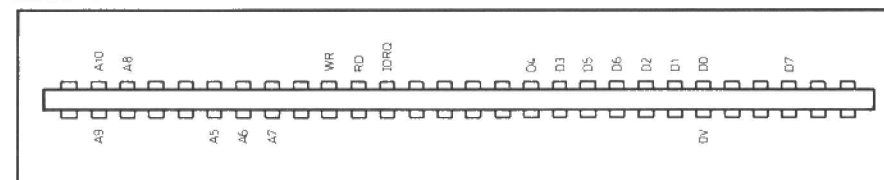


Fig. 3.2. Spectrum connection details

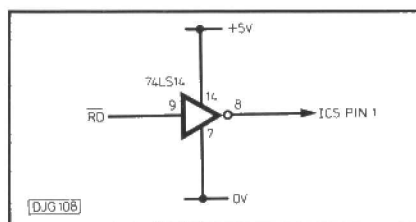


Fig. 3.3. For use with the MTX machines, pin 1 of IC5 must be driven from the RD line via an inverter

MTX500/512

The Memotech machines use standard Z80 interfacing with IORQ and the eight least significant address lines being used, giving an address range of 0 to 255. There are some unallocated addresses from 16 to 30, but there is insufficient space here for the Hobby Bus. Address from 32 upwards are unused internally, and are free for use on a machine which has no expansion other than the internal RS232C port. The suggested method of connection and switch settings place the Hobby Bus at addresses from 128 to 159, but by altering the settings of S4, S6, and S7 the unit can be placed in other 32 address blocks, and can be placed where it will not interfere with other add-ons.

A slight problem arose when using the Hobby Bus with an MTX500, in the form of corrupted data when reading the PIA, and occasional system crashes when accessing the unit. This seems to be due to a problem with spurious enabling of IC5 when it is set to the send mode (and is placing data onto the computer's data bus). The same problem did not occur with other

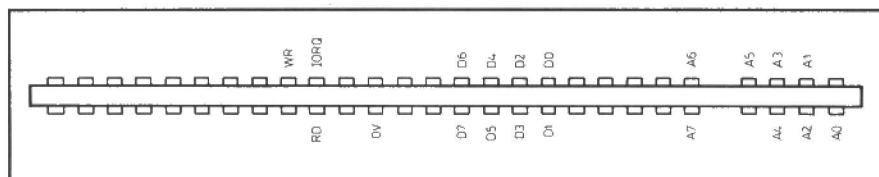


Fig. 3.4. MTX connection details

Z80 based computers, except in a much milder form on the Enterprise and CPC6128 where it caused very occasional glitching during read operations. However, this simple modification will completely cure the problem and can be used with an MTX computer or any other Z80 machine which exhibits the same problem. All that is necessary is to drive pin 1 of IC5 from

Table 3.5. The pIA and slot addresses for various computers

DEVICE	Amstrad (Hex)	Spectrum	MTX	Enterprise
8255 (A)	F8E0	63519	128	0
8255 (D)	F8E1	63583	129	1
8255 (C)	F8E2	63647	130	2
8255 (con)	F8E3	63711	131	3
SLOT 1	F8E4	63775	132	4
SLOT 1	F8E5	63839	133	5
SLOT 1	F8E6	63903	134	6
SLOT 1	F8E7	63967	135	7
SLOT 2	F8E8	64031	136	8
SLOT 2	F8E9	64095	137	9
SLOT 2	F8EA	64159	138	10
SLOT 2	F8EB	64223	139	11
SLOT 3	F8EC	64287	140	12
SLOT 3	F8ED	64351	141	13
SLOT 3	F8EE	64415	142	14
SLOT 3	F8EF	64479	143	15
SLOT 4	F8F0	64543	144	16
SLOT 4	F8F1	64607	145	17
SLOT 4	F8F2	64671	146	18
SLOT 4	F8F3	64735	147	19
SLOT 5	F8F4	64799	148	20
SLOT 5	F8F5	64863	149	21
SLOT 5	F8F6	64927	150	22
SLOT 5	F8F7	64991	151	23
SLOT 6	F8F8	65055	152	24
SLOT 6	F8F9	65119	153	25
SLOT 6	F8FA	65183	154	26
SLOT 6	F8FB	65247	155	27
SLOT 7	F8FC	65311	156	28
SLOT 7	F8FD	65375	157	29
SLOT 7	F8FE	65439	158	30
SLOT 7	F8FF	65503	159	31

the RD line of the computer via an inverter, as shown in Fig. 3.3.

It is not difficult to implement this modification in practice, and there is provision for an extra d.i.l. i.c. on the Hobby Bus printed circuit board. It is quite easy to wire in the 74LS14, but note that the track feeding into pin 1 of IC5 must be cut close to IC5 so that this pin is only driven from the output of the additional inverter, and is cut off from IC3's output.

The MTX expansion port is a 2 by 30 way 0.1 inch pitch edge connector, but a Spectrum type connector is a better choice as it has a suitable polarising key, and no connections are made to the parts that a Spectrum connector cannot reach. Wiring details are provided in Fig. 3.4.

THE PE HOBBY BUS

The MTX test program is given below. Like the Spectrum program, it reads port A rather than S2.

5 REM MTX TEST PROG

```
10 OUT 131,147
20 OUT 130,64
30 PRINT INP(128)
40 OUT 136,0
50 OUT 140,0
60 OUT 144,0
70 OUT 148,0
80 OUT 152,0
90 OUT 156,0
100 OUT 130,0
110 FOR D = 1 TO 100:NEXT
120 GOTO 20
```

ENTERPRISE

The Enterprise 64 and 128 both use the standard system of Z80 interfacing, and addresses below 128 are all left unused. The address decoder can therefore respond to just IORQ and A7 going low. Connections to the Enterprise expansion port are made by way of a 2 by 33 way 0.1 inch pitch edge connector, as shown in Fig. 3.5. The Enterprise test program is shown below, and this uses the BAND (binary AND) function to read S2.

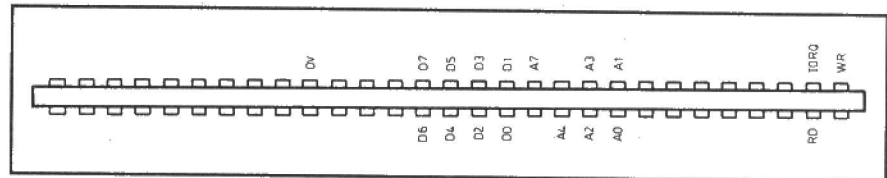


Fig. 3.5. Enterprise connection details

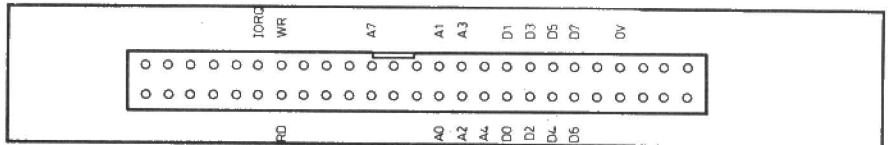


Fig. 3.6. MSX connection details

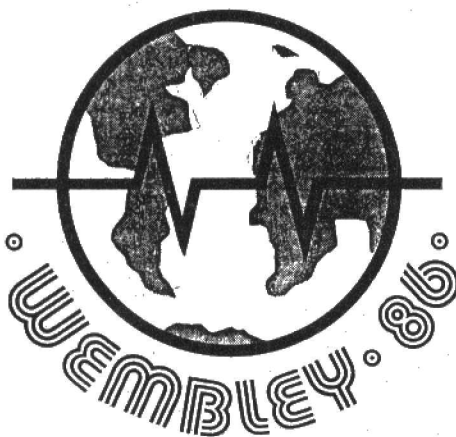
5 REM ENTERPRISE TEST PROG

```
10 OUT 3,147
20 OUT 2,64
30 PRINT IN(2) BAND 4
40 OUT 4,0
50 OUT 8,0
60 OUT 12,0
70 OUT 16,0
80 OUT 20,0
90 OUT 24,0
100 OUT 28,0
110 OUT 2,0
120 FOR D = 1 TO 100
130 NEXT
140 GOTO 20
```

MSX MACHINES

The unit has not yet been tried with an MSX computer, but like the Enterprise computers these have the lower half of the input/output map left vacant, and user add-ons are interfaced to them in exactly the same way. The MSX expansion port connector is a different type though, and a 50 way IDC header socket is required. Fig. 3.6 shows the necessary connections to this. Next month details of 6502 base computers will be given together with news of a range of exciting add-ons for the Hobby Bus including SBC's, IO and memory cards.

PE



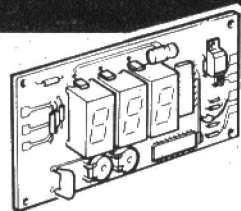
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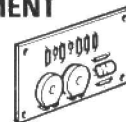


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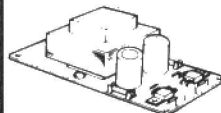
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ECHO AND REVERB EFFECTS UNIT

BY M. P. HORSEY

A low-cost sound box for weird and wonderful effects—crazy crescendo, erie echo and raucous reverberation

VARIOUS devices are employed to enable sound reverberation or echo effects. These include multiple head tape recorders and metal springs. In recent times 'bucket-brigade' delay line integrated circuits have become available. For example the type TDA 1022 provides theoretical delays of up to 51 milli-seconds. Unfortunately, the actual delay possible is very much less, and a number of these i.c.s have to be cascaded together.

A new bucket-brigade delay line i.c. has become available, which provides delays of three times longer duration. This i.c. is a type TDA 1097. While a little more expensive, only two such i.c.s are required to provide reverberation and echo effects.

A variety of sound effects can be obtained with this circuit. While designed for reverberation, the time delay can be sufficiently long to produce echo effects. In addition, the feedback may be increased to produce a crescendo effect—ideal for producing weird sounds.

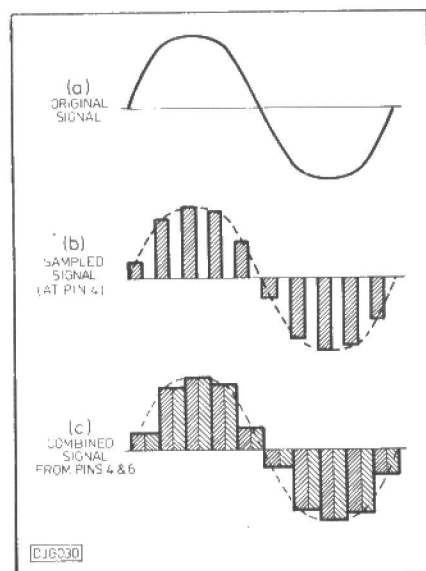


Fig. 1. Audio sampling

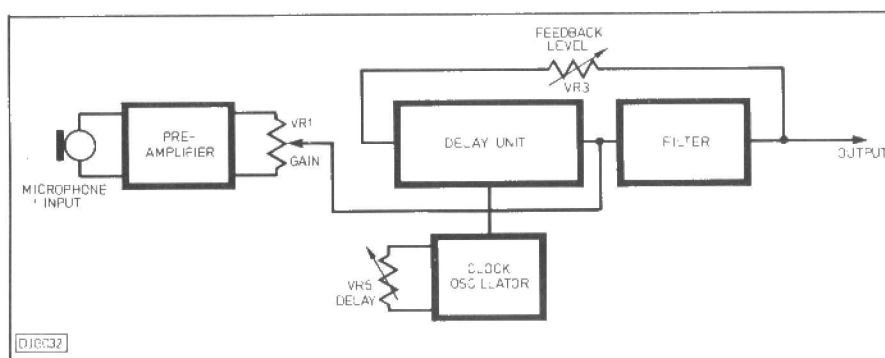


Fig. 2. System block diagram

PRINCIPLE OF OPERATION

The TDA 1097 is a 1536 stage delay line. Each 'stage' is a capacitor, fabricated with associated circuitry within the i.c. The audio (analogue) signal is divided into 'samples'—as illustrated in Fig. 1. Each sample represents a precise voltage, and is stored in the first capacitor CO, or 'stage'. Between successive capacitors is an electronic switch which transfers the charge from one capacitor to the next. Thus the 'sample' is transferred along the capacitors, rather like water being passed from one bucket to the next—as in the old method of fire-fighting. Hence the name 'bucket-brigade' delay line.

The time taken for samples to travel from one end to the other depends upon the number of stages and the rate at which the electronic switches operate. In this i.c. the number of stages is fixed at 1536. However, several i.c.s may be connected in 'series' if required. The switching rate is determined by a clock pulse fed to pins 1 and 2. The frequency of this clock pulse may be from 5kHz to 100kHz. However, in practice this frequency should be at least twice the maximum audio frequency required.

The circuit described is intended for the human voice, and the maximum

audio frequency chosen was 8kHz. The clock frequency is variable and ranges from about 12kHz upwards. At a clock frequency of 20kHz a delay of 38 milli-seconds per i.c. is provided. Thus with two i.c.s a delay of up to 76 milli-seconds is possible. Since the output is fed back into the i.c., reverberation can continue for some time.

ELECTRONIC FILTER

If electrical charges are to be passed from capacitor to capacitor it will be apparent that only alternate capacitors can actively hold the samples at any one time. The audio signal will therefore be very 'split up' as indicated in Fig. 1(b). Filtering such a signal is difficult—and would result in only half the maximum possible audio signal frequency indicated above. This fragmented audio signal is taken from the main output pin 4. An output is also provided from the PREVIOUS stage at pin 6. The charges at this stage fill in the gaps as shown in Fig. 1(c). Thus if pins 4 and 6 are connected together, the combined output provides greater continuity of signal and simplifies filtering.

This combined output is fed to an active filter comprising a 741 op-amp i.c. and associated resistors and capacitors. The effect of this circuit is to cut

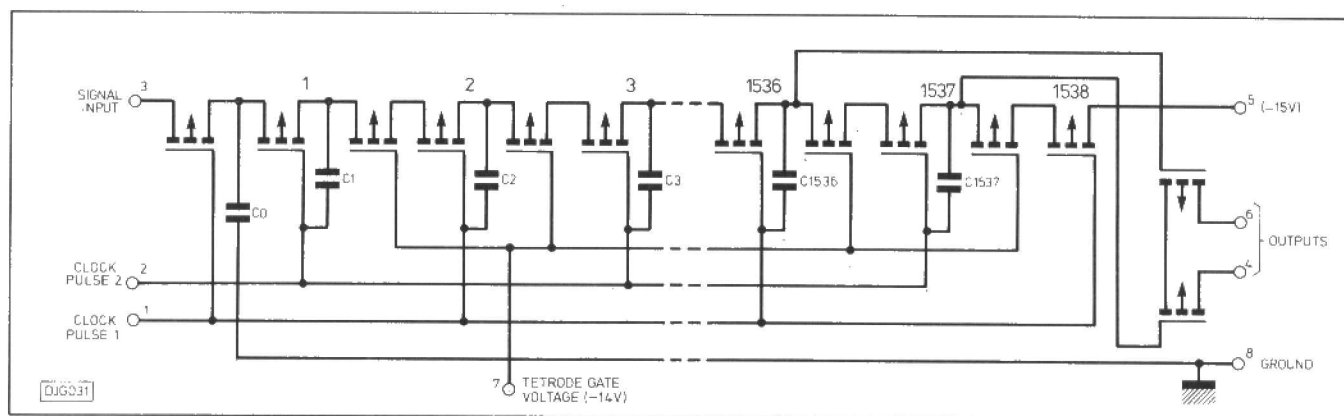


Fig. 3. Internal details of the TDA 1097

off all frequencies above 8kHz. Thus the 'bumpy' wave of Fig. 1(c) is reduced to a smooth audio wave similar to the input.

CIRCUIT ARRANGEMENT

It is important to note that the circuit employs a **POSITIVE EARTH** arrangement as shown in Fig. 4. This is unusual, and may cause confusion to the unwary observer. The arrangement will not affect the way in which the circuit is connected to other equipment, such as a power amplifier. The project consists of three main sections. These comprise the power supply, pre-amplifier, delay circuit and filter. A moving coil microphone may be connected to the input, and the output is sufficient to drive a power amplifier.

Larger input signals could be applied at capacitor C6 if required.

Variable resistor VR1 acts as a microphone level control; VR3 controls the amount of feedback and hence the total reverberation time, and VR6 controls the clock frequency, and hence the length of time for which the audio signal is delayed in IC2 and IC3.

MICROPHONE AMPLIFIER

A high gain amplifier (Fig. 4) based on a 741 i.c. increases the very low signal level produced by a moving coil microphone. The microphone signal is fed via d.c. blocking capacitor C1 to the non-inverting input of IC1. Resistors R1 and R2 hold this input at about -7 volts. The output from IC1 is fed back to the inverting input via R3, to

reduce the gain to an acceptable level. The frequency range is set by C2, C3 and R4. The output passes via d.c. blocking capacitor C4 to VR1—the microphone level control.

DELAY AND FILTER CIRCUITS

The amplified audio signal passes via R5 and C6 to the filter circuit comprising IC4 and associated components (described later). Part of the output from IC4 passes via VR3 and C9 to the input of the bucket-brigade delay line IC2. The d.c. voltage at pin 3 is held at -7 volts by means of VR2 and R9. Capacitor C7 decouples the junction between VR2 and R9. Pin 5 of IC2 is connected to -15 volts; pin 8 to zero volts, and pin 7 to about -14 volts as set by the resistor chain R6, R7, VR2

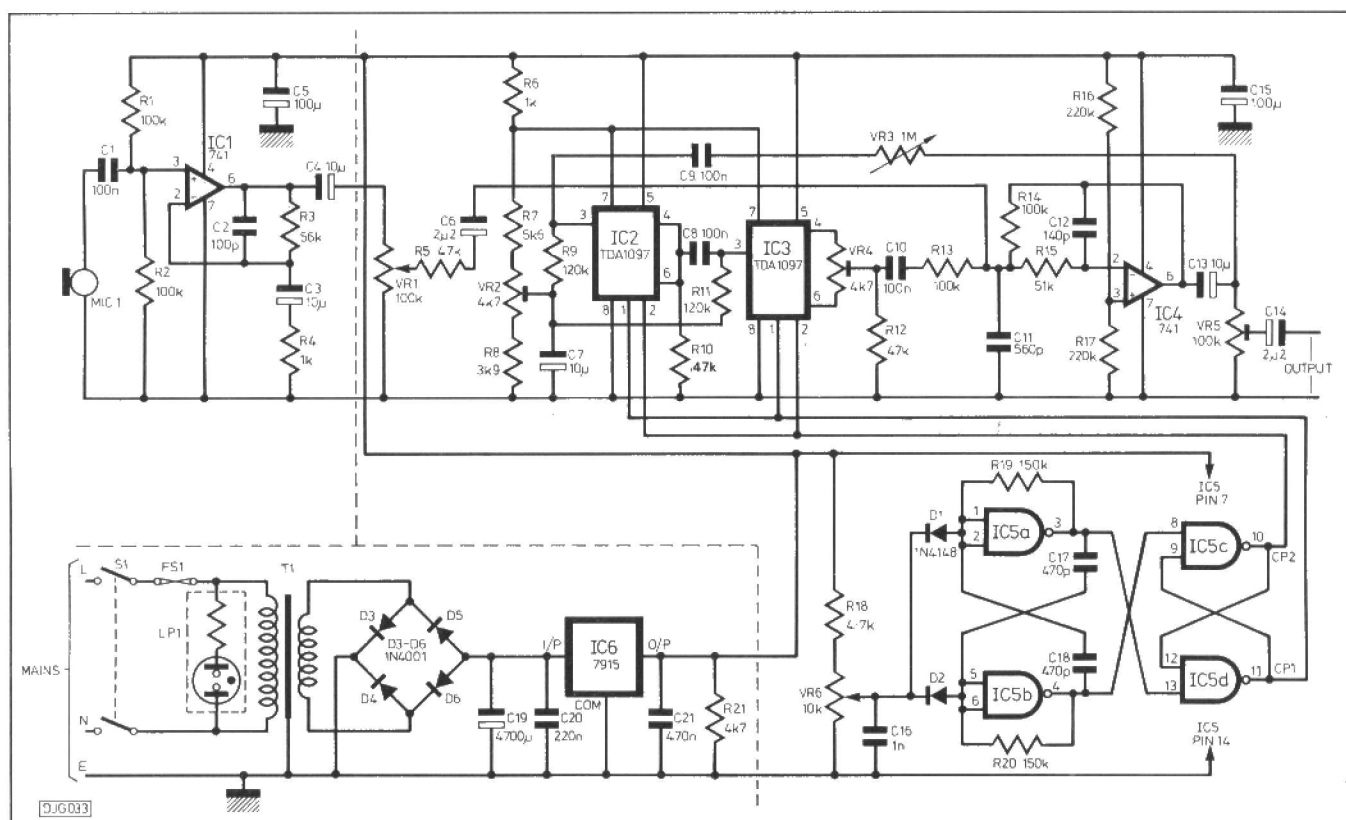


Fig. 4. Complete circuit diagram

and R8. The clock inputs are connected to pins 1 and 2.

The delayed output from IC2 is taken from pins 4 and 6, and the signal is fed via d.c. blocking capacitor C8 into the next delay line IC3. This i.c. is connected in exactly the same way as IC2, except that the outputs are connected via preset VR4. This should be adjusted for minimum distortion and ensures that the two sets of outputs are equal. (See 'Electronic filter' above for clarification).

The signal now passes into the inverting input of IC4. The resistor/capacitor network filters the signal, so that frequencies above about 8kHz are cancelled out. Pin 3 is held at about -7 volts by R16 and R17. Part of the output from pin 6 travels via VR3 and C9 to the input of IC2 as previously described, to complete the feedback loop. VR2 sets the feedback level and thus the length of time for which the signal reverberates.

The output from IC4 is also fed to the output socket via d.c. blocking capacitors C13 and C14. Preset VR5 allows the circuit to be correctly matched to a range of power amplifiers.

CLOCK SIGNALS

An inexpensive CMOS 4011 i.c. is used to supply the two antiphase clock pulses required by the delay line i.c.s. The arrangement of resistors and capacitors and use of all four gates provides a very clean symmetrical output wave, the frequency of which may be varied by means of a voltage applied to gates A and B via diodes D1 and D2. VR6 sets the voltage and hence the clock frequency. R18 limits the voltage, ensuring that the clock frequency cannot be increased too far.

Power is supplied by a fairly conventional arrangement comprising transformer T1 and four diodes. Smoothing is achieved by capacitor C19, with capacitors C20 and C21 removing any tiny spikes on the supply. The -15 volt supply is provided by negative voltage regulator IC6, which is a type 7915. Capacitors C5 and C15 provide additional decoupling for the microphone amplifier and delay/filter circuits respectively. The components specified will supply up to about 60mA d.c., which is more than sufficient. A greater current output transformer may be employed if the power supply is required to drive a power amplifier as well. No alteration need be made to the other power supply components if the d.c. output required is less than 1 amp, although a heat sink will be necessary for IC6.

CUTTING COSTS

The delay line i.c.s TDA 1097 are rather expensive and some construc-

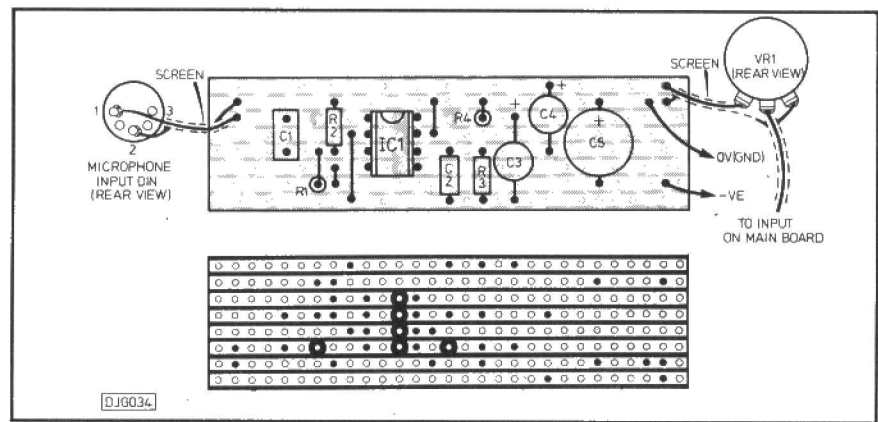


Fig. 5. Amplifier construction details

tors may prefer to build the circuit with one rather than the two shown. It is recommended that the circuit be built with all the i.c. holders and wire links, so that the second TDA 1097 may be added later. If only one delay line i.c. is used, leave out IC2 and C8, and take C9 to pin 3 of IC3 instead of IC2. The maximum delay possible will now be halved, but quite interesting reverberation effects can still be obtained.

MICROPHONE AMPLIFIER CONSTRUCTION

The microphone amplifier circuit is sensitive to electrical interference, and it seemed prudent to construct it separately (Fig. 5), to allow additional screening. As with all amplifiers, neatness of wiring is important to prevent the circuit picking up electrical noise and feedback. Begin by breaking the tracks as shown. Then solder in the i.c. holder, wire links, resistors and small capacitors. Note that the electrolytic capacitors must be connected with the correct polarity. Plug in the 741 i.c. the correct way round. No special handling precautions are required.

Screened cable should be used at the input and output. Note that the screen is connected to positive (earth).

TESTING

The microphone amplifier circuit should be tested separately. Connect a suitable moving coil microphone, and feed the amplifier output to the tape or tuner input of a power amplifier. The circuit may be powered from a 9 volt battery if required; do not forget that positive must be connected to ground. The signal obtained from the microphone amplifier should be similar to that obtained from a tape recorder or tuner.

POWER SUPPLY CONSTRUCTION

The few components required for the power supply may be mounted on a

piece of stripboard near the mains transformer as shown in Fig. 6. A heat sink is not required for IC6 as it is working well below its rated current output. A 100mA minus 15 volt regulator is available, and may be used if preferred. There is little price advantage however. Make sure that the large electrolytic capacitor C19 is connected with the correct polarity—noting POSITIVE/EARTH again. Note that track C is deliberately left unconnected.

MAIN CIRCUIT CONSTRUCTION

The delay line, filter and clock pulse generator are constructed on a single piece of stripboard as shown in Fig. 7. Label the stripboard carefully, and break the tracks where indicated, noting that the position of each break is critical in both directions. Holders are essential for the CMOS bucket-brigade delay lines, IC2 and IC3 and CMOS IC5. It is wise to use a holder for IC4 as well.

The holders, wire links and components may be soldered in as usual, noting the polarity of the diodes and electrolytic capacitors C6, C7, C13, C14 and C15. Screened cable should be employed to link VR2 with the circuit, and at the signal input and output. The screen must be connected to POSITIVE. IC4 should be inserted into its holder the correct way round, but DO NOT plug in the delay line i.c.s at this stage.

IC5 should be inserted into its socket, noting that it is a CMOS i.c., and requires careful handling. (See 'Handling precautions' below.)

MAINS WIRING

Keep all mains wiring as short as possible and away from the audio parts of the circuit. The mains 'earth' lead should be connected to the metal core of the transformer, and to the metal case of the project. The 'earth' connection should also be joined to the 'posi-

ECHO/REVERB UNIT

tive' (zero volts) line of the power supply.

Connect the power supply to both the microphone amplifier and delay/filter circuits. Connect the voltmeter across the power supply as before, and switch on. Switch off immediately if the voltage appears to fall below 15 volts. The likely cause of this is a bridged pair of tracks, or other short circuit—or either circuit connected with the wrong polarity.

If all is well, switch off and connect the microphone amplifier to the main circuit, and the main circuit output to a power amplifier. Set VR1 and the presets to about mid way.

Switch on the supply and speak into the microphone. The signal from the microphone amplifier should pass through the filter circuit and be heard via the power amplifier. No reverberation will occur as the delay line i.c.s have not yet been fitted. Adjust preset VR5 for good matching into the power amplifier and set VR1 for a reasonable microphone volume level.

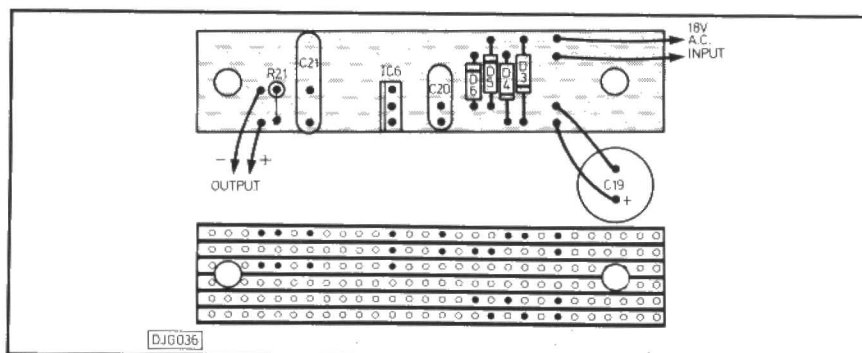


Fig. 6. Power supply construction details

The clock oscillator may be checked at this stage if an oscilloscope is available. Alternatively a high impedance earpiece may be connected across CP1 and CP2. When VR6 is turned fully clockwise (maximum delay, minimum frequency) a high pitched sound should be heard.

If all is well, switch off and short circuit the power supply to ensure that the capacitors are discharged before fitting IC2 and IC3.

HANDLING PRECAUTIONS

All CMOS i.c.s should be handled with care, as the static electricity which appears on insulated materials—including the human body—can easily destroy the i.c. The high cost of the bucket-brigade delay line i.c.s makes careful handling even more imperative.

Store the i.c.s in their original packaging material until the moment of

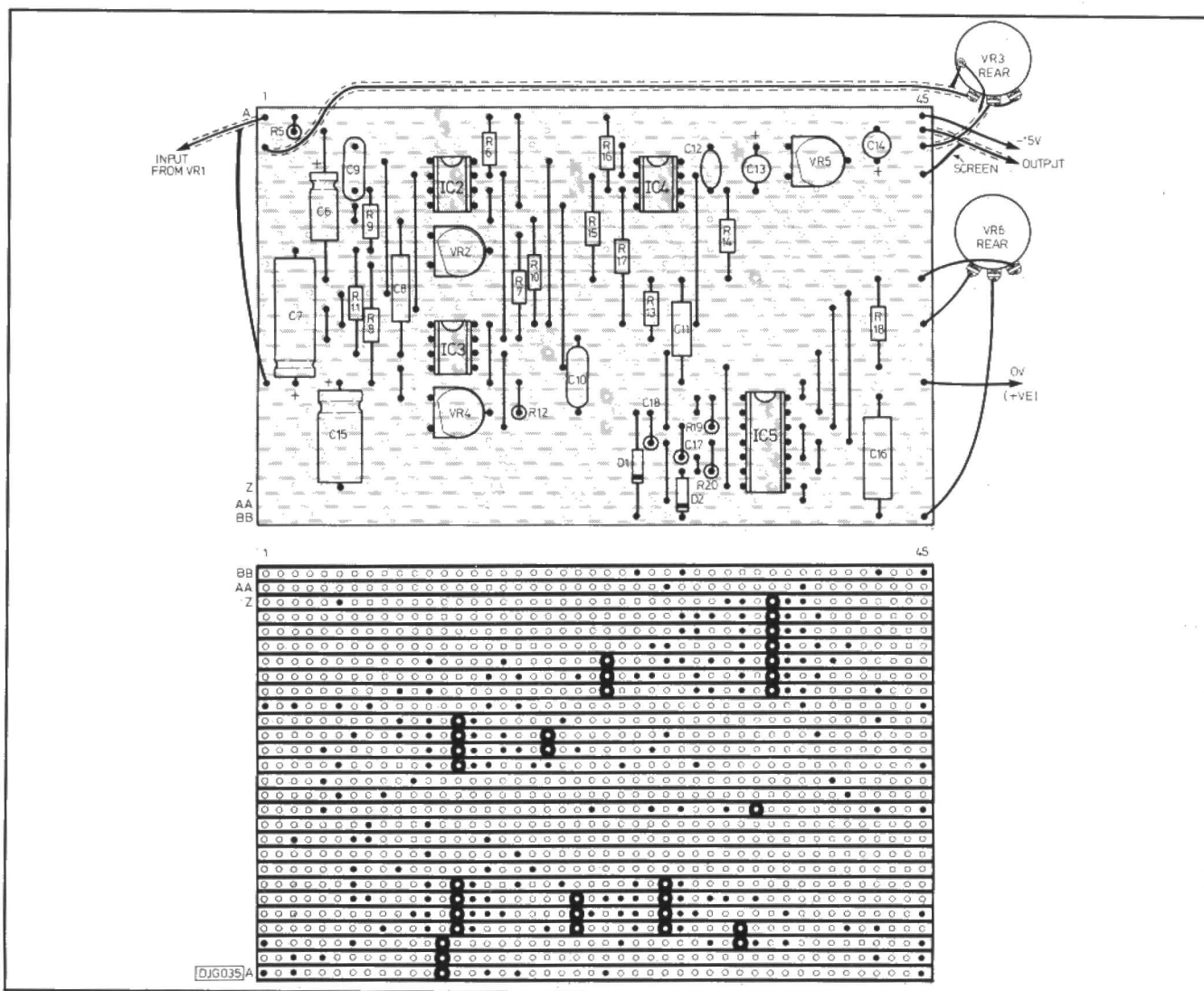


Fig. 7. Main circuit construction details

ECHO/REVERB UNIT

insertion into their holders. 'Earth' your hands by touching an earthed metal object (for example the metal case of a power unit plugged into the mains). Proper earthing straps which fit around the wrists are available from some components suppliers.

Place the i.c. packaging material against the destination socket to ensure that they are equally charged.

Make sure that the i.c. is facing the correct way and insert into its socket. Once fitted, the other components in the circuit will protect it from electrostatic effects, PROVIDING no alterations are made. If any further soldering is required, first remove IC2 and IC3, taking the same precautions as before and returning them to their original protective packaging.

FINAL TESTING

The circuit may now be tested. Set reverberation control VR3 to minimum resistance (maximum feedback). Switch on and adjust the delay control (VR6) to maximum delay (fully clockwise). A high pitch whistle may be heard. Turn up VR6 a little until the noise can no longer be heard. Any sound made into the microphone

should reverberate. Adjust VR3 so that the reverberation decays rather than increases.

Adjust preset VR2 so that the voltage between its sliding contact and ground is -7 volts. In other words connect the POSITIVE lead of the voltmeter to 'ground' and touch the

negative lead to the sliding contact of VR2 whilst adjusting VR2 for a 7 volts reading. Preset VR4 should be adjusted so that the two sets of signals from pins 4 and 6 of IC3 are equal. In the absence of an oscilloscope VR4 should be set for minimum distortion. Alternatively an oscilloscope may be used to

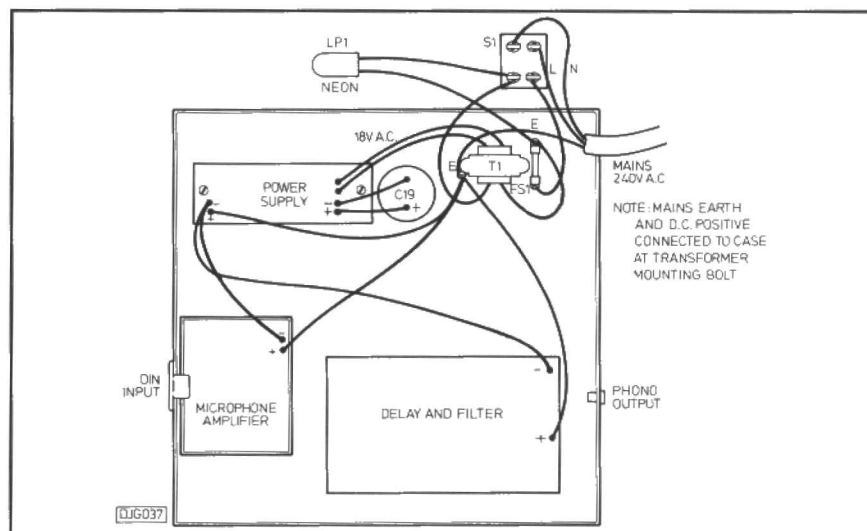


Fig. 8. Wiring diagram

COMPONENTS...

RESISTORS

R1,R2,	100K (4 off)
R13,R14	
R3	56K
R4,R6	1K (2 off)
R5,R10,	47K (3 off)
R12	
R7	5k6
R8	3k9
R9	120K
R11	120K
R15	51K
R16,R17	220K (2 off)
R18,R21	4k7 (2 off)
R19,R20	150K (2 off)

POTENTIOMETERS

VR1	100K linear pot.
VR2	4.7K preset
VR3	1M linear pot.
VR4	4.7K preset
VR5	100K preset
VR6	10K linear pot.

CAPACITORS

C1,C8,	100n polyester (3 off)
C10	
C2	100p polystyrene
C3,C4,	10μ electrolytic (4 off)
C7,C13	
C5,C15	100μ electrolytic (2 off)
C6,C14	2μ2 electrolytic (2 off)
C11	560p polystyrene
C12	140p polystyrene

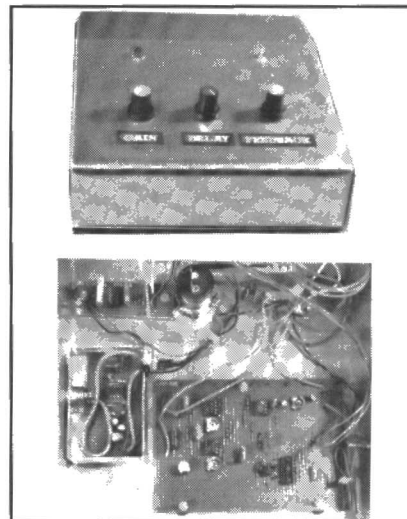
C16	1n polystyrene
C17,C18	470p polystyrene (2 off)
C19	4700μ electrolytic
C20	220n polyester
C21	470n polyester

SEMICONDUCTORS

IC1,IC4	741 op-amp (2 off)
IC2,IC3	TDA 1097 bucket-brigade delay line i.c.
IC5	CMOS 4011B
IC6	Regulator i.c. -15V type 7915
D1,D2	Diodes type 1N4148 (2 off)
D3-D6	Diodes type 1N4001 (4 off)

MISCELLANEOUS

T1	mains transformer 18V (or 15V) 100mA secondary
LP1	mains neon with integral resistor
S1	mains toggle switch
FS1	fuseholder and 200mA fuse
Stripboards: 45 holes by 28 tracks (plus extra for mounting holes); 29 holes by 8 tracks, 28 holes by 6 tracks; i.c. holders; din socket (for microphone) 5-way; phono socket (for output); knobs, 3 off; mains cable; screened cable, connecting wire; grommets; screws; nylon nuts and bolts; metal cases as described; wire; solder; etc.	



monitor the signal at the sliding contact of VR4. Using a fairly high time-base setting the two sets of component frequencies should be visible. VR4 should now be adjusted until the heights of these two sets of waves are equal.

Assuming the earlier tests were successful, any failure at this stage suggests a mistake in the few components and links around IC2 and IC3. If necessary, check the voltage across pins 5 and 8 of each i.c. A reading of 15 volts should be obtained. Connect the positive lead of the voltmeter to 'ground' and check that pin 7 is at about -14 volts, and pin 3 at about -7 volts. If all is well the circuits may be fitted into a suitable case.

PE

SPACEWATCH

BY DR PATRICK MOORE OBE

*Light on the dark comet
and future cometary encounters*

THE space scene during the first half of 1986 has been dominated by four vehicles—three successful, one tragic. There have been the immensely valuable unmanned craft, Voyager 2 to Uranus and Giotto to Halley's Comet (not forgetting, of course, the other members of the Halley armada, two Japanese and two Russian). In the field of manned flight, the Soviet authorities have sent up their Mir space-station, which is much the most ambitious so far. The disaster of the *Challenger* Shuttle is, of course, uppermost in all our minds, and quite apart from the human tragedy it has dealt a devastating blow to the whole of American space research. As a tribute to the crew, it has been officially announced by the LAU Minor Planet Centre that seven asteroids will be named in honour of the crew members: 3350 Scobee, 3351 Smith, 3352 McAuliffe, 3353 Jarvis, 3354 McNair, 3355 Onizuka and 3356

Resnik. All these asteroids were discovered between 1980 and 1984 by E. Bowell and N. Thomas at the Lowell Observatory in Arizona.

(Other asteroids have recently been named after contemporary astronomers: 1945 Wesselink, 2561 Roman, 3225 Hoag and 3299 Hall—the third of these after the current Director of the Lowell Observatory. I cannot resist adding that Asteroid 2602, discovered by Bowell in 1982, has been officially named 'Moore' after me!)

The first two cosmonauts of the Mir station, taken there by Soyuz 15, are Leonid Kizim and Vladimir Solovyov, and it may be of interest to say something about them.

Kizim was born at Krasny Liman, in the Donetsk region, on 6 August 1941. In 1963 he graduated from the Chernigov pilots' school, and then, after a spell in the Air Force (during which he became a test pilot) he joined the

cosmonauts unit. In 1980 he commanded Soyuz 3 and the orbital station Salyut 6. His second flight, lasting 237 days, was made in 1984 as commander of Salyut 6; he was joined by Solovyov, who had been born in Moscow on 11 November 1946 and had become a cosmonaut in 1978.

The Mir station is presumably permanent. How long Kizim and Solovyov will stay in it remains to be seen, but it has been suggested that the Russians are seriously considering a manned mission to Mars—in which case it is essential to carry out long-term experiments under conditions of zero gravity.

THE DARK COMET

It will take years to evaluate all the results obtained from the Giotto encounter with Halley's Comet on 13 March, but already some surprising

The Sky This Month

HALLEY's Comet remains well above the horizon this month; but it has faded so much that telescopes of some size are now needed to show it, and we must reconcile ourselves to the fact that the main part of the current apparition is over. Though the comet will be tracked for some years yet, it will not again be a naked-eye object until the year 2061.

Of the planets, Mercury is an evening object, at elongation on the 25th, but it will be best seen around mid-June, low above the WNW horizon as soon as the sky becomes dark enough. Venus, however, cannot possibly be missed in the west after sunset, as its magnitude is -3.4 —much brighter than any other object in the sky apart from the Sun and the Moon. Mars, in Sagittarius, is brightening, and will be at opposition on 10 July; at present its magnitude is -2 , superior to any star (even Sirius), though from British latitudes it is rather inconveniently low. Saturn is not far from Mars, and the rings are wide open, so that telescopically the planet is a glorious sight. Jupiter continues to be seen in the south-east during the early hours of the morning.

The Ophiuchid meteor shower appears from the 17th to the 26th, but the expected hourly rate is not high. There are no eclipses during June; the Moon is new on the 7th and full on the 22nd.

Evening skies are dominated by what is now usually called the Summer Triangle, consisting of the three brilliant stars Vega (in Lyra), Altair (in Aquila) and Deneb (in Cygnus). This was a nickname which I used

in a television Sky at Night programme over twenty years ago, and it seems to have passed into the literature, though it is completely unofficial—and is naturally inapplicable to the southern hemisphere, where the Triangle is seen in evenings during winter!

It is interesting to compare the three stars: Vega is a glorious blue, and is near the zenith; Altair is easily recognised by the presence of a fainter star to either side; Deneb, in the Cross of Cygnus, is much the faintest of the three, but it is also much the most remote, and is at least 60,000 times the power of the Sun. Were it as close to us as Altair, it would cast shadows. Appearances can be deceptive.

Antares, low over the southern horizon, also has a fainter star to either side, but there is no danger of confusion with Altair, if only because Antares is so red; its name means 'the Rival of Mars'. It is rather interesting to compare the two, which is easy at the moment because they are not very far apart—though of course Mars is very much the brighter of the two. Look also for the starclouds in Sagittarius, following Antares round; they are magnificent in binoculars, and of course they indicate the direction of that mysterious region, the centre of the Galaxy.

The Great Bear is high up, and so is Arcturus, in Boötes (the Herdsman), a lovely light orange colour. Arcturus is fractionally brighter than Vega, and is surpassed by only three stars, all in the southern hemisphere of the sky (Sirius, Canopus and Alpha Centauri).

facts have come to light—and of these, the most remarkable is the colour of the nucleus. Instead of being ice-bright, as most people had expected, it has proved to be black. The albedo is no more than 2 per cent, and there are not many objects in the Solar System as dark as that. The nucleus is also somewhat larger than had been anticipated; it is some 12 kilometres long by 8 kilometres broad.

There still seems little doubt that Fred Whipple's 'dirty iceball' theory is essentially correct; nothing else can explain the characteristics of comets. But it is now clear that the dark 'dust' layer is much deeper than expected, and acts as an effective insulator; otherwise the ices would evaporate much more quickly than they actually do. And what is the nature of the dark material? Is it organic—perhaps some sort of 'tar'? This is at least possible, and it brings us straight on to the theories proposed by Sir Fred Hoyle and his colleague Professor Chandra Wickramasinghe.

Just before the Giotto encounter, when I was at Darmstadt (headquarters of the European Space Organization) Professor Wickramasinghe rang me up, and repeated his contention that the nucleus of Halley's Comet would prove to be dark. I admit that I was somewhat sceptical, and almost

everyone else at Darmstadt shared my view; but Wickramasinghe was right, and we were wrong.

According to the Hoyle-Wickramasinghe viewpoint, comets are carriers of life. They roam around the cosmos, and it was a comet which brought life to Earth in the first place—together with most of the water in our oceans. This is not all. Comets are essentially organic, and may deposit viruses in our atmosphere, resulting in epidemics. From a medical standpoint this idea has been regarded as outrageous, and something not to be taken seriously; neither have astronomers in general been at all impressed. Yet the Halley revelations make one think very hard indeed. As I have said elsewhere, Hoyle and Wickramasinghe have won the first round.

"he was right and we were wrong"

Of course, it would be hopelessly premature to suggest that the 'outlandish' theories about diseases from space have been proved simply by the fact that the nucleus of Halley's Comet is black rather than bright, but it is also true to say that before the Giotto pass it was thought very unlikely that organic materials would be found in any quantity. The essential need now is to

find out just what the dark material really is.

Also, are comets genuinely interstellar—as is believed not only by Hoyle and Wickramasinghe, but also by other eminent astronomers, notably Victor Clube and Bill Napier of Edinburgh? The accepted theory is that comets were 'left over', so to speak, when the planets were formed, more than 4.5 thousand million years ago, so that the 'dirty iceballs' are now orbiting the Sun at a distance of at least a light-year, and enter the inner Solar System only when they are perturbed by some agency or other. The concept of the Oort Cloud (named in honour of Jan Oort, who also was at Darmstadt) has not been seriously challenged over the past few decades, but there is no proof of its existence.

For the moment we can only await the full analyses of the Giotto findings, and hope for more cometary encounters in the foreseeable future.

If Hoyle and Wickramasinghe prove to be correct in all their views, we will have to do some radical re-thinking. Most authorities will still doubt whether this will be necessary, but it must also be admitted that their theories sound rather less outlandish now than they did before that exciting night when Giotto passed right through the coma of Halley's Comet. **PE**

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4007	13p 4501	38p 74LS83	28p 74LS273	52p AN-1114	AN-1115	180p	LM380
4008	38p 4502	32p 74LS88	43p 74LS279	40p AN-1120	AN-1120	140p	LM381
4009	29p 4503	32p 74LS89	45p 74LS280	140p AN-1270	AT-1270	380p	LM382
4010	21p 4504	55p 74LS90	32p 74LS283	30p 7400	22p AY3-1350	300p	LM383
4011	13p 4505	200p 74LS91	75p 74LS365	37p 7401	18p AY3-8910	380p	LM384
4012	13p 4506	80p 74LS92	38p 74LS366	37p 7402	18p AY3-8912	400p	LM385
4013	19p 4508	70p 74LS93	30p 74LS367	35p 7403	22p AY3-3600	570p	LM386
4014	35p 4509	37p 74LS95	47p 74LS368	38p 7404	40p CA270	40p	LM387
4015	34p 4510	40p 74LS96	32p 74LS373	55p 7405	10p CA3046	60p	LM388
4018	18p 4511	40p 74LS107	32p 74LS374	55p 7406	40p CA3048	190p	LM389
4017	31p 4512	42p 74LS109	34p 74LS375	55p 7407	40p CA3080E	280p	LM390
4018	31p 4514	75p 74LS112	36p 74LS399	80p 7408	25p CA3086	55p	M-5151SL
4019	35p 4515	75p 74LS113	32p 74LS870	72p 7409	28p CA3089E	150p	M-5151L
4020	35p 4516	40p 74LS114	32p 74LS122	40p 7413	35p CA3090AD	300p	M-5151L
4021	36p 4517	120p 74LS123	40p 74LS123	42p 7414	45p CA3130E	100p	MB3712
4022	36p 4518	30p 74LS124	85p 2114	200p 7420	32p CA3130S	100p	MB3730
4023	36p 4519	30p 74LS125	38p 27256	400p 7421	22p CA3140E	38p	MB3756
4024	25p 4520	30p 74LS126	38p 2532	330p 7425	25p CA3140E	280p	MB3756
4025	13p 4521	50p 74LS132	40p 2716	200p 7437	25p CA3240E	80p	NE555
4026	60p 4521	40p 74LS133	34p 2732	280p 7442	25p HA-115W	150p	NE555
4027	18p 4522	44p 74LS136	35p 2764	240p 7447	60p HA-119	190p	SAS560
4028	35p 4526	40p 74LS138	35p 27128	250p 7450	10p HA-1306WR	170p	SAS570
4029	17p 4529	75p 74LS139	35p 4115	75p 7451	10p HA-1368	170p	SN75003N
4030	30p 4532	52p 74LS145	80p 4194	110p 7454	25p HA-1377	220p	SN75110N
4031	54p 4551	180p 74LS146	80p 6116	160p 7470	30p HA-1389	140p	TA-7148P
4032	80p 4553	23p 74LS151	32p 6264-15	250p 7473	40p HA-1392	230p	TA-7149P
4033	80p 4555	38p 74LS153	40p 6502	300p 7474	40p HA-1397	250p	TA-7200
4034	80p 4556	190p 74LS154	90p 6802	220p 7475	25p HA-1398	240p	TA-7201
4035	45p 4558	38p 74LS155	41p 6809	600p 7481	80p LA-1201	80p	TA-7203
4036	48p 4564	30p 74LS156	47p 6821	140p 7485	78p LA-1352	120p	TA-7204
4037	75p 4583	74p 74LS157	30p 6840	310p 7488	38p LA-1395	140p	TA-7205
4038	180p 4585	42p 74LS158	33p 6850	110p 7489	80p LA-3301	120p	TA-7210
4040	36p	74LS160	48p 6850A	320p 7492	80p LA-3350	120p	TA-7222AP
4041	36p	74LS161	50p 9085A	320p 7490	115p LA-3361	115p	TA-7210P
4042	36p	74LS162	48p 8155	390p 7493	45p LA-4031	140p	TBA550
4043	36p	74LS163	48p 8156	360p 7496	45p LA-4032	140p	TBA120S
4044	36p	74LS164	48p 8224	270p 7497	45p LA-4050	130p	TBA395
4045	72p	74LS165	80p 8226	270p 74107	80p LA-4051	180p	TBA398
4046	45p	74LS166	74p 8226	270p 74107	30p LA-4101	120p	TBA520
4047	45p	74LS167	82p 8228	270p 74111	52p LA-4102	100p	TBA530
4048	45p	74LS168	82p 8230	270p 74115	85p LA-4103	100p	TBA540
4049	45p	74LS169	85p 8243	250p 74118	85p LA-4112	260p	TBA550
4050	20p	74LS170	80p 8250	850p 74122	80p LA-4125	210p	TBA750
4051	38p	74LS171	39p 8251	300p 74123	40p LA-4140	70p	TBA800
4052	37p	74LS172	55p 8253	340p 74125	40p LA-4220	120p	TBA805
4053	37p	74LS173	55p 8255	350p 74126	40p LA-4220	120p	TBA820
4054	52p	74LS174	52p 8256A	120p 74126	40p LA-4220	120p	TBA820
4055	52p	74LS175	52p 8257A	370p 74132	42p LA-4420	140p	TBA950
4056	52p	74LS176	51p 8259	370p 74141	40p LA-4430	130p	TBA990
4060	40p	74LS180	53p 8271	4400p 74153	45p LA-4480	170p	TCA800
4063	52p	74LS181	52p 8272	130p 74155	45p LA-4481	180p	TCA940
4066	20p	74LS182	52p 8279	850p 74157	45p LA-5112	120p	TDA1170
4067	130p	74LS183	52p 8282	400p 74160	50p Phase add 50p and VAT at 15% Govt. Colleges.	100p	
4068	13p	74LS184	55p 8283	400p 74164	50p		
4069	13p	74LS185	55p 8284	500p 74167	50p		
4070	13p	74LS186	55p 8285	500p 74173	50p		
4071	13p	74LS187	55p 8286	500p 74174	50p		
4072	13p	74LS188	55p 8287	500p 74175	50p		
4073	13p	74LS189	55p 8288	500p 74176	50p		
4074	13p	74LS190	55p 8289	500p 74177	50p		
4075	13p	74LS191	55p 8290	500p 74178	50p		
4076	45p	74LS192	55p 8291	500p 74179	50p		
4077	13p	74LS193	55p 8292	500p 74180	50p		
4078	13p	74LS194	55p 8293	500p 74181	50p		
4079	13p	74LS195	55p 8294	500p 74182	50p		
4081	13p	74LS196	55p 8295	500p 74183	50p		
4082	13p	74LS197	55p 8296	500p 74184	50p		
4083	40p	74LS198	55p 8297	500p 74185	50p		
4084	40p	74LS199	55p 8298	500p 74186	50p		
4085	40p	74LS200	55p 8299	500p 74187	50p		
4086	32p	74LS201	55p 8300	500p 74188	50p		

SEMICONDUCTOR CIRCUITS

BY PETER FINCH

The Intel 8052AH-Basic microcomputer chip —a versatile, programmable controller

A new product launched by Intel reminded me of the first microprocessor based computer I owned over ten years ago. It was one of the very first micro computers produced, an 8080 with 4K of memory, in an early S100 crate with front panel, data and address indicators and switches. When one switched on, a simple boot program had to be loaded into the machine using the front panel switches—a tedious task. The boot program allowed one to load a program from paper tape via an attached ASR33 teletype terminal. One of the first pieces of software I acquired for this system was a small 3K Basic interpreter. It was a very limited version of Basic, integer only, had no functions and took 30 minutes to load the paper tape. Having loaded the Basic one had less than 1K of RAM to use for Basic programs—a very limited system.

Intel have now put a whole computer system with a full 8K Basic interpreter onto a single chip. This new chip is the ideal solution for anyone wishing to put a microprocessor into a project but who for a variety of reasons may be unwilling to write the controlling program in machine code. Basic programs are much easier and quicker to write and also more easily modifiable.

The 8052AH-Basic chip contains an 8Kbyte full featured Basic interpreter on a ROM which is part of the processor chip. The version of Basic employed differs slightly from the fairly standard Microsoft Basic found on many home computers. The Intel Basic is designed primarily for running real time control applications and there are therefore many new commands which are processor specific I/O handling commands. Although the 8052AH-Basic does support full floating point arithmetic it is not designed as a number crunching processor.

I think this chip would make the ideal basis for a simple single board computer which could be used as the basis of a wide range of projects. It could amongst many different applications be the processor controlling a

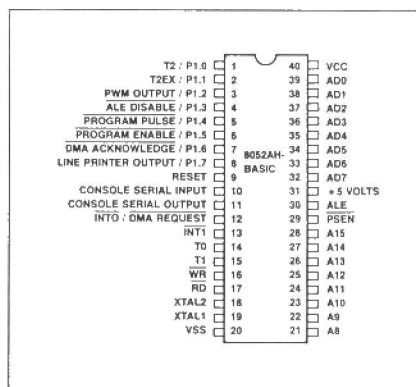


Fig. 1. Pin-out diagram

small mobile robot, it could run a household control system, or it could be the basis of a remote data acquisition system. The serial communications links on the chip could be connected to a home micro and used to transfer programs and data. Programs could be written and debugged on the home micro first before being either down loaded into RAM or committed to EPROM.

SYSTEM HARDWARE DESIGN

The 8052AH-Basic is an enhanced version of the 8051 and owes its origin to the ever popular 8080 microprocessor with which it shares a common instruction set. Inspection of the internal architecture of the 8052AH-Basic shows that besides having 8Kbytes of ROM in which Basic resides, and 256 bytes of scratchpad RAM, the chip also includes two 16-bit counter/timers, a serial communications port and a parallel I/O port. A pin out diagram and a basic description of the pin functions is shown in Fig. 1 and Table 1 respectively.

SYSTEM SOFTWARE

The most important feature of the 8052AH-Basic is its resident software. This is, after all, a 'software on silicon' product. The resident Basic interpreter-Basic-52—is specifically designed

to address the needs of process control, measurement and instrumentation applications. The rationale for using a Basic interpreter is simply that Basic programming is well understood and much simpler and easier to write and understand than comparable assembly language programs.

All the standard Basic commands and functions are included in Basic-52 such as full floating point arithmetic and transcendental operations. There are in addition a considerable number of unique features which allow the user to perform tasks which normally require assembly language routines. These include bitwise logical operators such as AND, OR, and EXCLUSIVE-OR as well as hexadecimal arithmetic and built in radix conversion. There are also a range of machine specific statements which are designed for real time control applications. These statements can initialise counters and timers, control a real time clock, handle interrupts, examine and modify memory locations as well as performing all serial and parallel I/O functions. These special machine specific statements allow every feature of the 8052 to be utilised directly from a Basic program with no need to resort to assembly code. A complete list of the commands and statements of Basic-52 are shown in Table 2.

The serial channels are very important on chip features since they allow the communication of programs and data between the chip and an external terminal. On power up the Basic-52 sets its baud rate to match the baud rate of the attached terminal. Timer2 is used as a baud rate generator. In addition to the terminal serial input and output lines there is also a serial printer port. This port is output only and can be software set to any required baud rate, it is a useful additional feature of the 8052 chip.

All direct I/O operations are performed through the eight lines of Port 1 on the 8052AH-Basic chip. The eight lines of this port can only operate in the output mode under Basic-52 since there are no statements to input any

Table 1. 8052AH pin designation and brief description

VSS

Circuit ground potential.

VCC

Circuit supply voltage. 5 volts $\pm$ 10% relative to VSS.

AD0-AD7

The multiplexed low-order address and data bus used during accesses to external memory. External pullup devices ($\sim 10K \Omega$) are required on these pins if the MCS BASIC-52 EPROM/E²PROM programming feature is used.

A8-A15

The high order address bus used during accesses to external memory.

PORT 1

A general purpose quasi-bidirectional 8-bit input/output port. The individual pins on PORT 1 all have alternate functions which may or may not be implemented by the user. The alternate functions are as follows:

PORT 1.0 (T2)

Can be used as the trigger input to TIMER/COUNTER 2. A one (1) must be written to this port pin output latch in order for this function to operate. Details of the T2 trigger function are covered in the Microcontrollers Handbook. Order Number 210918-002.

PORT 1.1 (T2EX)

Can be used as the external input to TIMER/COUNTER 2. A one (1) must be written to this port pin output latch in order for this function to operate. Details of the T2 trigger function are covered in the Microcontroller Users Manual.

PORT 1.2 (PWM OUTPUT)

This pin is used as the PWM output port when the PWM statement is executed. PWM stands for Pulse Width Modulation and is used to generate pulses of varying duty cycle and frequency.

PORT 1.5

(PROGRAMMING ENABLE)

When the EPROM/E²PROM programming feature is implemented, this pin is used to enable the EPROM programming voltage. This pin remains active (logically low (0)) during the entire EPROM programming process. On E²PROM devices that do not require any special programming voltage, this pin is not used.

8052AH-BASIC is an 8052AH device; however, MCS BASIC-52 assumes a particular hardware configuration. The following pin description outlines the pin functions defined by MCS BASIC-52.

PORT 1.6

(DMA ACKNOWLEDGE)

When the DMA feature is implemented as described in the MCS[®] BASIC-52 users manual, this pin functions as an active low DMA ACKNOWLEDGE output.

PORT 1.7

(LINE PRINTER OUTPUT)

This pin functions as a serial output port when the LIST # or PRINT # command and/or statement is used. This enables the user to make a "hard copy" of a program or to print out results of a calculation.

RESET

A high (2.5 volts) on this pin for two machine cycles while the oscillator is running resets the device. An external pulldown resistor ($\sim 8.2K$) from RESET to VSS permits power-on reset when a capacitor ($\sim 10\mu f$) is connected from this pin to VCC.

ALE

ALE (address latch enable) is an output pin that is used to latch the low order address byte during Read, Write, or program fetch operations to external memory.

PSEN

This pin (Program Store ENable) is a control signal that is used to enable external program memory. In MCS[®] BASIC-52, this pin will always remain inactive (logically high (1)) unless the user is running an assembly language program in external memory.

XTAL1

Input to the inverting amplifier that forms the oscillator.

XTAL2

Output of the inverting amplifier that forms the oscillator, and input to the internal clock generator. Receives the external oscillator signal when an external oscillator is used.

PORT 1.3 (ALE DISABLE)

This pin is used to disable the ALE signal to the external address latch when the EPROM/E²PROM programming feature is used. In a system, this pin is logically anded with ALE.

PORT 1.4

(PROGRAMMING PULSE)

When the EPROM/E²PROM programming feature is used, this pin provides the proper programming pulse width to program EPROM and INTELLIGENT EPROM[®] devices. MCS BASIC-52 actually calculates the proper programming pulse width from the system crystal value (XTAL) to assure the proper timing of this pulse. When used to program E²PROM devices, the length of this pulse is not critical. This pin is active in the logical zero (0) state.

RD

A control signal that is used to enable READ operations to external data memory. This pin is active low (0).

WR

A control signal that is used to enable WRITE operations to external data memory. This pin is active low (0).

T1

This pin can be programmed to be an external input to TIMER/COUNTER 1.

T0

This pin can be programmed to be an external input to TIMER/COUNTER 0.

INT1

This pin is the external interrupt 1 pin. It is active low and interrupts on this pin may be handled in either BASIC or in assembly language.

INT0/DMA REQUEST

This is the external interrupt 0 pin. It is active low and may be optionally programmed to function as a DMA request input pin. The DMA REQUEST pin is used by E²PROM devices during programming.

CONSOLE SERIAL OUTPUT

This is the serial output pin to the console device. Standard ASCII codes are used as well as a standard asynchronous frame.

CONSOLE SERIAL INPUT

This is the serial input pin that receives data from the console device. Standard ASCII codes are assumed to be the input and the data is assumed to be transmitted using a standard asynchronous frame.

data from this port. Any of the logical operations may be performed upon this byte-wide output port in order to manipulate individual lines. However, each of the individual pins on this output port have alternate functions which may or may not be implemented by the user, a list of these alternate functions is shown in Table 1.

A minimal amount of extra hardware is required in order to support Basic-52. A very simple system consists of the 8052AH-Basic, 1Kbytes of external memory, a latch to demultiplex the address and data lines, and the appropriate serial port drivers. As an interesting extra feature Basic-52 can program an EPROM or EEPROM connected to the address and data bus lines using a program pulse line from the 8052. This program line is derived from one of the user port lines and with the addition of a transistor, a gate and a couple of passive components to give the required voltage level is used by Basic-52 to generate the programming

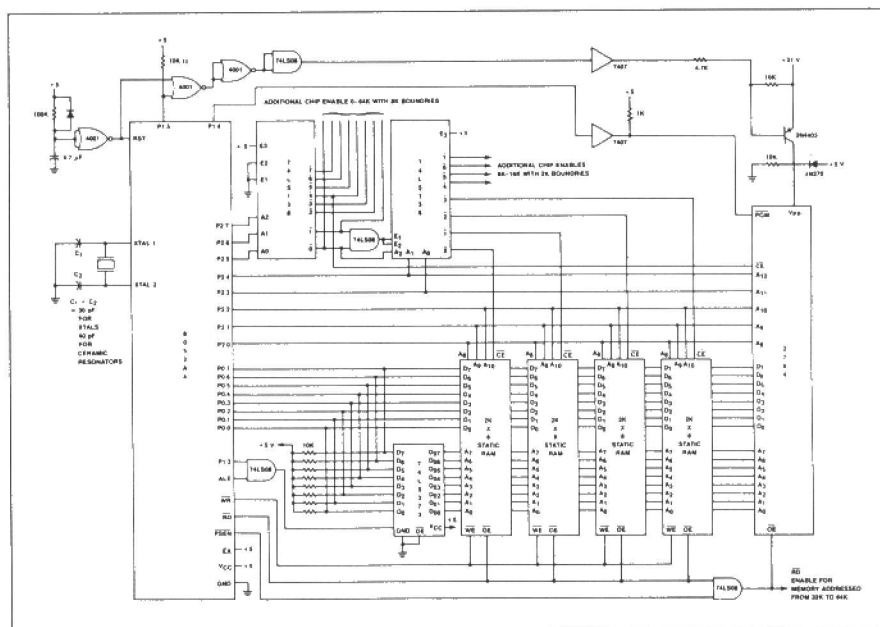


Fig. 2. Minimal system circuit diagram

Table 2. MCS[®] Basic-52 software feature set

COMMANDS	STATEMENTS	OPERATORS
RUN	BAUD	ADD (+)
LIST	CALL	DIVIDE (/)
LIST#	CLEAR	EXPONENTIATION (**)
NEW	CLEAR	MULTIPLY (*)
NULL	CLEAR1	SUBTRACT (-)
RAM	CLOCK0	LOGICAL AND (.AND.)
ROM	CLOCK1	LOGICAL OR (.OR.)
XFER	DATA	LOGICAL X-OR (.XOR.)
PROG	READ	LOGICAL NOT
PROG1	RESTORE	ABS ()
PROG2	DIM	INT ()
FPROG	DO-WHILE	SGN ()
FPROG1	DO-UNTIL	SQR ()
FPROG2	END	RND
	FOR-TO-STEP	LOG ()
	NEXT	EXP ()
	GOSUB	SIN ()
	RETURN	COS ()
	GOTO	TAN ()
	ON-GOTO	ATN ()
	ON-GOSUB	=, >, <, >=, <=
	IF-THEN-ELSE	<, <=, >, >=
	INPUT	ASC ()
	LET	CHR ()
	ONERR	CBY ()
	ONEXT1	DBY ()
	ONTIME	XBY ()
	PRINT	GET
	PRINT#	IE
	PH0.	IP
	PH0.#	PORT1
	PH1.	PCON
	PH1.#	RCAP2
	PUSH	T2CON
	POP	TCON
	PWM	TMOD
	REM	TIME
	RET1	TIMER0
	STOP	TIMER1
	STRING	TIMER2
	UI0	TIME
	UI1	XTAL
	UO0	MTOP
	UO1	LEN
		FREE
		PI

pulses. A circuit diagram for a minimal system is shown in Fig. 2.

USING THE 8052AH-BASIC

The concept of 'software on silicon' devices has been around for several years with devices like the Z8. But these were usually in software terms fairly limited devices owing to the limited amount of ROM available on chip. The 8052 with 8Kbytes of on chip ROM has broken this limitation and I am confidently expecting to see other versions of this chip become available supporting other languages such as Forth. Having the system control software already on the chip makes this device very easy to use, and because the applications software is written in Basic the time taken to implement a system using this device can be minimal.

I think that the great advantage of this processor chip to the amateur is in developing ideas which require a microprocessor without having to invest large amounts of time in software development. In this way projects can be tried out and the hardware developed, later, when the project is working. The software could be rewritten in machine code on any one of the single chip microcomputers now available. This chip is expensive (in one off quantities £50 each) but considering its power and versatility this is not a lot to pay for what is basically a small computer especially if it is used in prototyping applications.

For prototyping purposes the chip can be incorporated into a simple system on a single card incorporating either 8 or 16Kbytes of RAM memory and an EPROM socket with program-

ming circuitry plus the line drivers required to implement an RS232 communications link. A simple system like this would easily fit onto a single Eurocard and could be attached via the address and data bus to the hardware system under development. The serial I/O lines could be used to download programs and data from a home micro like the BBC. When the software was fully debugged it could be committed to EPROM using the inherent ability of the 8052AH-Basic to programme EPROMs.

CONCLUSION

In conclusion I think that this chip should find a considerable number of applications from everyone wishing to use microprocessors to control a project. In the past people have tended to use a small cheap micro like the ZX81 as the controller, but this always had the limitation of confining the user to the inherent limitations of the computer. By using a chip like the 8052AH-Basic the user is freed from many if not all of these limitations. I intend to use

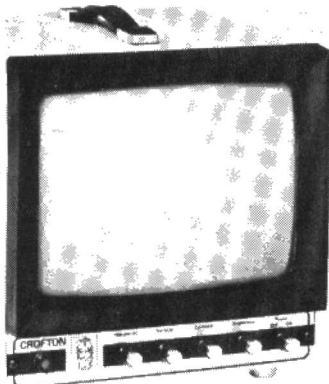
*The 8052AH-Basic is available from:
Rapid Recall Ltd, Rapid House,
Denmark St, High Wycombe, Bucks. Tel:
0494 26271.*

this chip in future projects and I am certain that it will become a very powerful component in the armoury of many electronics and computer system designers as a very cost and time effective way of developing micro-processor based projects. **PE**

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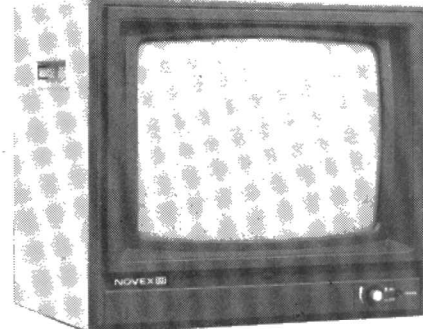
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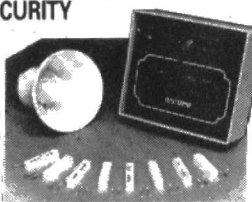
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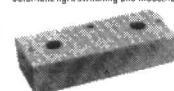
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BBC MICRO FORUM

BY RAY STUART

Memory magic and minor modifications

IN THE April issue of BBC Micro Forum we discussed the 1MHz bus and indicated that an extra 32K (or 64K) bytes of RAM can be added to the system. In this month's BBC Micro Forum we will look at the interface circuitry required to implement this extra RAM. In addition we will discuss the problem of interfacing devices from outside the 65XX range of chips.

The 1MHz bus should be buffered so that bus lines are only loaded by one LSTTL load, and terminated with 2K2 resistors as discussed in the April issue. Fig. 1 shows one method of buffering the 1MHz bus. The uni-directional lines of the address and control buses are buffered by 74LS244s and the bi-directional data bus by a 74LS245. The buffered outputs are identified by prefixing them with 'B', thus the buffered A1 line is called BA1. The BR/W line is used to control the direction of data via the 74LS245.

EXTENDED PAGE MEMORY CIRCUIT

The full circuit diagram for the extended page memory is shown in Fig. 2. The 1MHz bus lines are terminated by 2K2 resistors as described above, however, the buffering arrangements are slightly different. The bus lines are buffered by IC1 to IC4. The data and address lines are each buffered by a 74LS245. The 5 control lines (RST, NPFC, NPFD, 1MHzE and R/W) are buffered by two 74LS04 i.c.s. The inverted R/W line, available on IC1 pin 6 is used to indicate the data flow direction. This signal is fed to pin 1, the direction control input of IC3 the data bus buffer. As the address bus only operates in one direction, its direction control input is tied to Vcc.

Although this buffer circuit is different to that shown in Fig. 1, its function is the same. In this case the control lines are buffered by two 74LS04s as the following circuit requires both the normal and inverted forms of the reset line, RST, and the R/W line. Both NPFC and NPFD, the page select lines are 'cleaned' by ICs 5 & 6 both 74LS02s as described in April's BBC Micro Forum.

It will be noted that the NPFC line is inverted before being used as part of the decoding circuit for address

&FCFF, the paging register. This decoding is performed by IC7, a 13-input NAND gate whose output is used to activate an 8-bit latch type 74LS273. This latch therefore holds the value present on the data bus when data is written to address &FCFF. Thus the output of the 74LS273 provides the upper eight address lines necessary to address up to 64K bytes of additional RAM.

The upper three address lines (A15, A14 and A13), are decoded into eight chip select lines by IC9, a 74LS138, together with the BNPF line. Thus the chip select lines are only valid, and hence the RAMs enabled, when an address between &FD00 and &FDFF is accessed. In the April BBC Micro Forum it was stated that Acorn have recommended that only the upper half of the possible 64K bytes of RAM

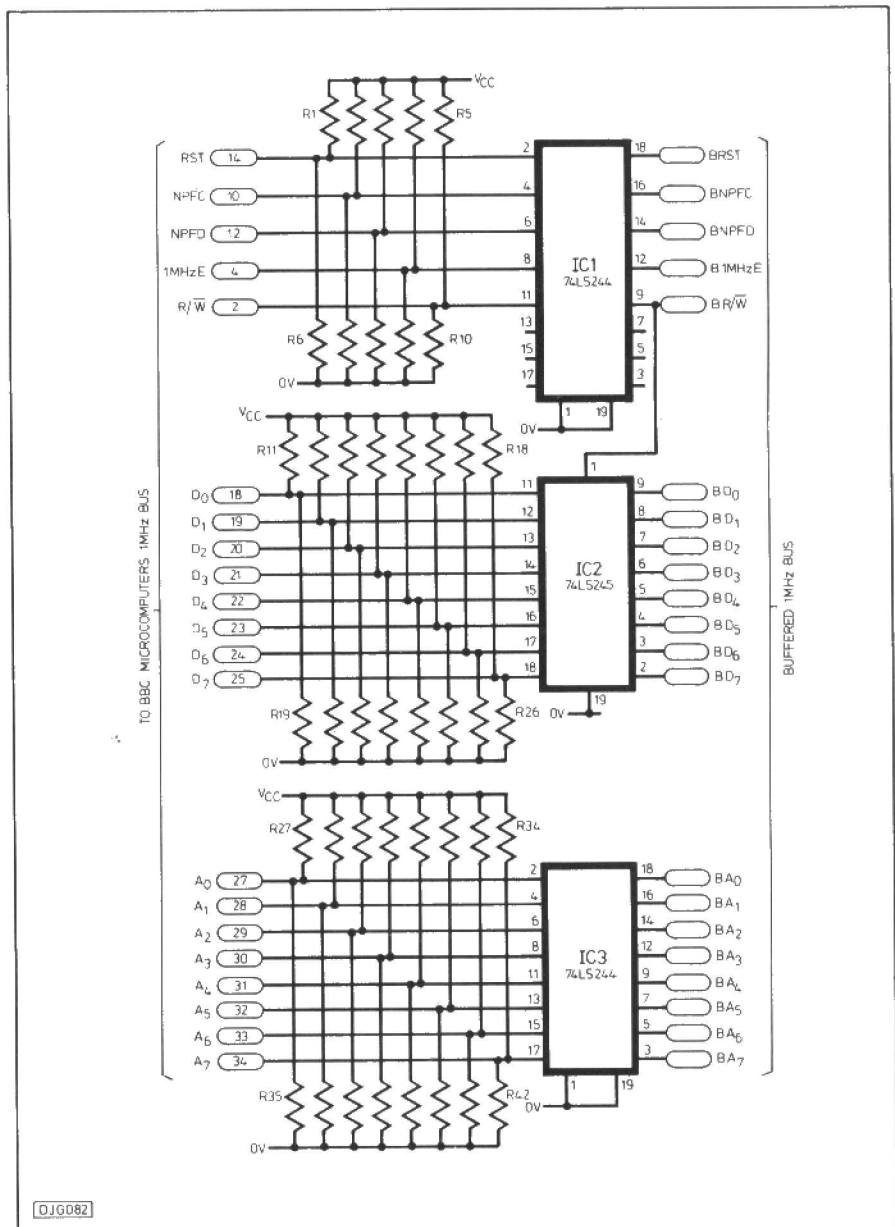


Fig. 1. Bus buffers

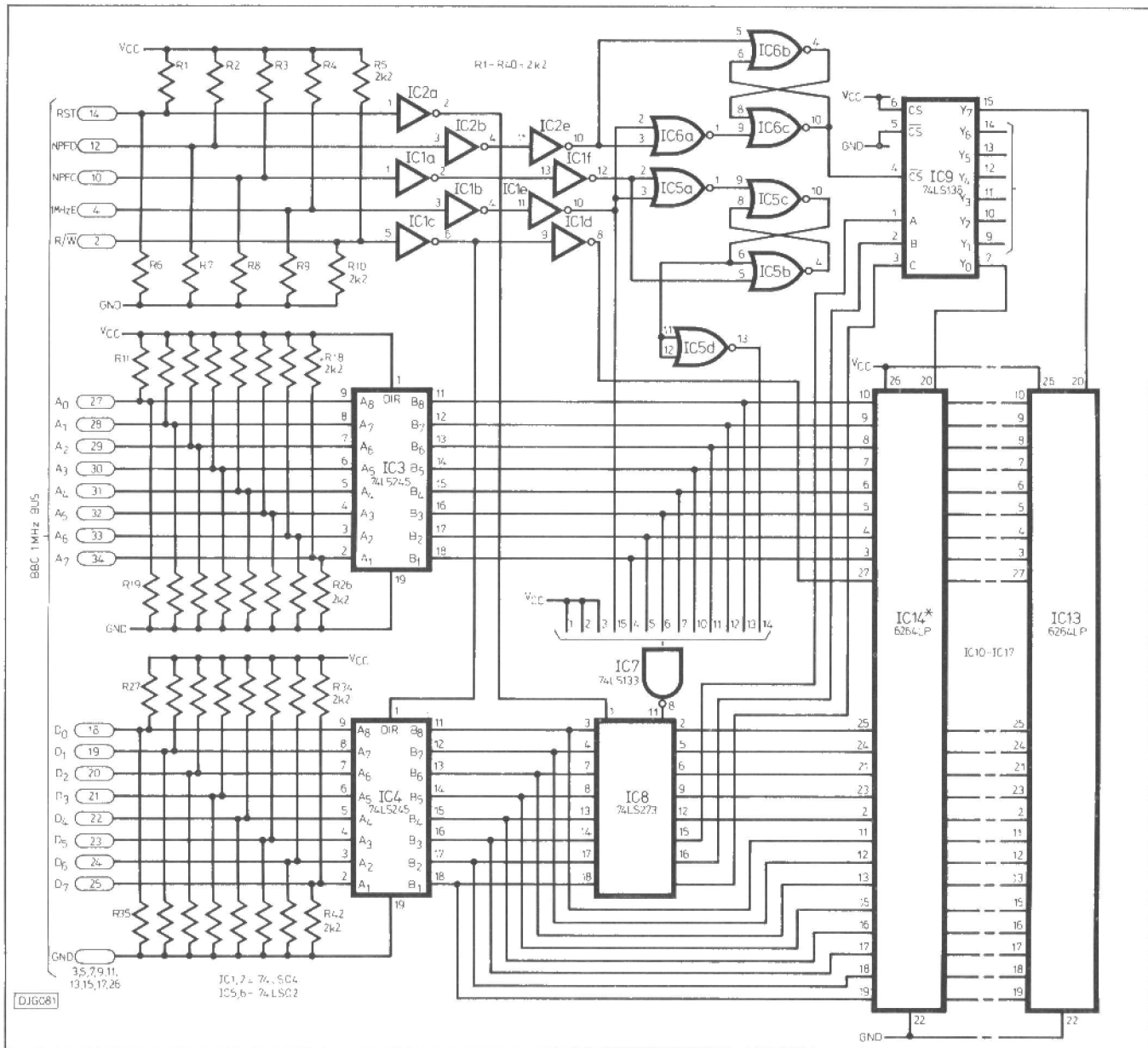


Fig. 2. Extended page memory

should be allocated to user applications. This block of RAM consists of IC10 to IC13 (all 6264LPs). However, if the RAM circuit is not to be used with other 1MHz peripherals, then the full 64K bytes can be used. In this case IC14 to IC17 provide the additional 32K byte of RAM.

Acorn also specify that the paging register, IC8 in this circuit, should be reset to &00 whenever the BBC micro-computer is switched on or a break command is issued. The RST line from the 1MHz bus is therefore inverted and fed to IC8 pin 1, the chip's reset input.

Addressing a specific memory location within the extended page memory consists of two stages. Firstly the paging register has to be set to the upper byte of the address. This is achieved by writing this value to address &FCFF. When this has been set, up to 256 bytes can be accessed by reading or writing to NPFD (&FD00-&FDFF). The soft-

ware procedures required for this were described in the April BBC Micro Forum.

BATTERY BACK-UP

The RAMs used in this circuit are low power devices that only require about 50 microamps per chip in order to retain their data. Thus it is possible to add battery back-up to the RAMs allowing data to be stored whilst the BBC system is switched off. There are two possible methods of providing battery back-up, rechargeable NiCad battery or primary lithium battery.

A 3-6V NiCad battery can be added by means of the circuit shown in Fig. 3a. When the circuit is powered by a 5V supply, diode D2 is reversed biased and therefore no current flows from the battery to the RAMs. However, current determined by R1 flows into the battery thereby charging it. If the

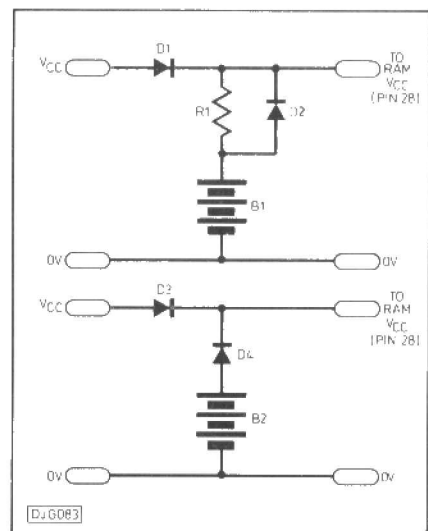


Fig. 3. Battery back-up

5V supply is removed the battery is connected to the RAMs thereby allow-

ing data to be retained. Under these conditions the battery is isolated from the remainder of the circuitry by D1. This type of battery back-up circuit relies on the battery being sufficiently charged. In applications where the system is not used for prolonged periods, the battery does not receive a full charge resulting in data being lost. Remember that it is usually necessary to charge a NiCad battery for about 14 hours for a full charge.

This problem can be overcome by using a primary cell battery. A lithium battery of 3V is ideal for this application. Fig. 3b shows how such a battery can be connected. Under normal use where the 5V supply is present, the battery is isolated by the reversed biased D4 but becomes forward biased when the 5 volt supply is removed. Printed circuit board mounted lithium batteries are available that can provide CMOS RAMs with about 10 years back-up.

NON 65XX SERIES PERIPHERAL CHIPS

Although there is a wide range of useful devices in the 65XX range, there are applications where other devices are more suitable. However, most of these cannot be directly connected to the 1MHz bus. These devices differ from those of the 65XX series in that they require separate read ($\overline{RD}$) and write ($\overline{WR}$) inputs as opposed to the single $R/\overline{W}$ of the 65XX range. Intel 82XX and Zilog Z80-XXX series devices are the most commonly available peripheral devices of this type.

The operation of this type of device is such that the $\overline{RD}$ and $\overline{WR}$ inputs should only be taken low when a read or write operation is undertaken. In order to achieve these conditions the circuit shown in Fig. 4 is used. The $R/\overline{W}$ line is required in both the normal and inverted versions. This is achieved by using two of the six inverters (1a & 1b) contained within a single 74LS04. The remainder of the 74LS04's inverters can be used as buffers for the other control lines on the 1MHz bus. The reader will notice that this approach has been used for the extended page memory.

These signals are then qualified with the buffered 1MHzE signal by the two

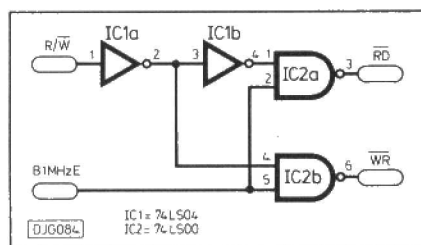
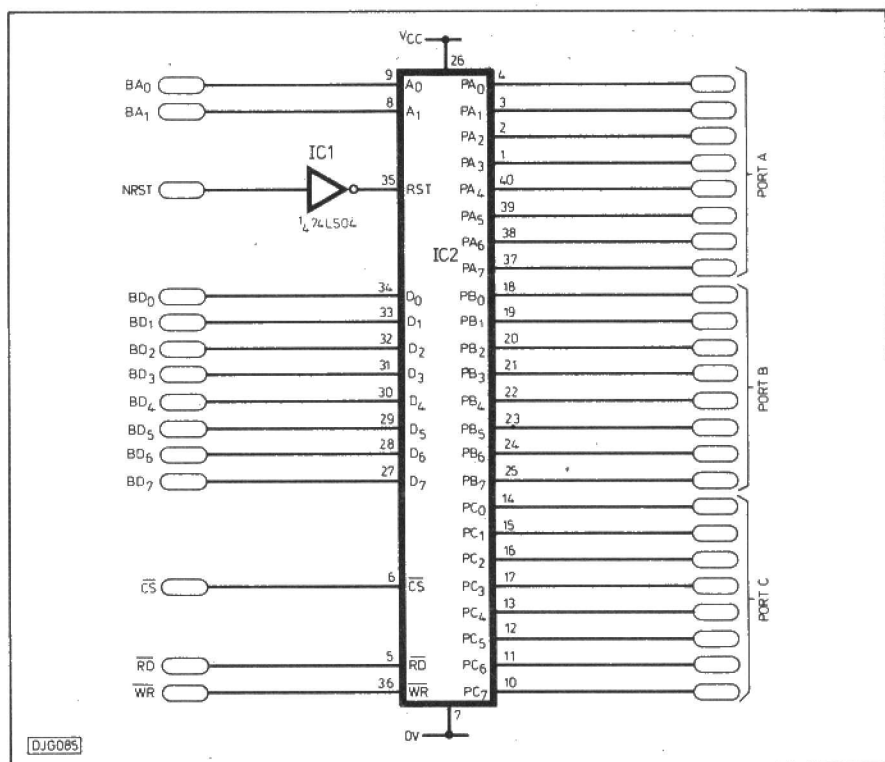


Fig. 4. $\overline{R}$ and $\overline{W}$ conditioning



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COMMENT . . .

Where Are All The Women Engineers?

LAST year the female membership of the Institution of Electrical Engineers for the first time exceeded the 1,000 mark. This was hailed as a milestone, but after taking into account that the organization's total membership is over 85,000, one realises there is small cause for celebration.

The scarcity of women engineers in Britain has long been a recognized problem. As early as 1919 the Women's Engineering Society was trying to alleviate it by encouraging women to enter the male-dominated field. With the "boiler suits and spanners" image that engineering had, and entrenched stereotypes about men and women's roles, the organization had its work cut out.

It was helped with its task five years later by the creation of the Electrical Association for Women. To commemorate the 21st birthday of the E.A.W. in 1945, the association established the Caroline Haslett Memorial Trust. Named after the association's first director, the trust's aim was to provide financial help for women to become engineers and scientists.

In a further effort to attract women to the engineering profession, the Trust collaborated with the Institution of Electrical and Electronics Engineers in 1978 to introduce the Girl Technician Engineer of the Year award. Every year since then a prize of £250 has been given to an outstanding female technician engineer under the age of 30 in the hope that she will serve as a model for other women to emulate.

Despite these encouraging developments, however, the number of women

engineers has been slow to rise. When the Committee of Inquiry into the Engineering Profession published its report in 1980, it commented on the problem: "... less than half of the current stock of engineers are women. Engineering has thus been recruiting from only half of the population. Girls now comprise a little over three per cent of all engineering students, which is a marked improvement on past showing but is still minimal considered that ... 42 per cent of graduate scientists from universities are women. We would welcome an increase in the proportion of women graduating in engineering and urge all concerned to work towards this goal."

Four years later, the Engineering Council took up the call. In conjunction with the Equal Opportunities Commission, the council named 1984 "Women Into Science and Engineering (WISE) Year" and launched a campaign in schools to encourage girls to consider careers in the science and engineering professions.

Ron Kirby, the council's Director of Public Affairs, says that stereotyped attitudes about engineering being an unsuitable profession for women has been the biggest obstacle the campaign faced. "Slowly we're getting the message across that engineering is not a dirty job," he said. "New technology and computerization is giving it the right image of being a clean job." That, in addition to an increasing willingness among employers to hire women engineers, makes him optimistic about the future of women in the profession.

But he admits the current figures don't bear that optimism out. A mere

one per cent of the 505,000 registered and chartered engineers in Britain are women. That compares with three per cent in Western Europe and nine per cent in America.

That's hardly a good record for a country desperately trying to keep pace with its industrial competitors. If Britain wants to avoid becoming what the Prince of Wales earlier this year called a "fourth-rate country" things must change. To keep up with the competition (Japan has five times the number of engineering graduates as Britain), Britain can no longer afford to "recruit from only half of the population."

Clearly the profession and the government, by giving awards and launching educational campaigns, have done their part. What more must be done to remedy this situation?

Attitudes are difficult to change but stagnation and decline await the society that refuses to adapt them to fulfil its needs. Britain needs more engineers and women can go a long way towards filling that gap. The attitude that certain professions are "unsuitable" for women is outdated and it's time parents and teachers recognized that. They must provide encouragement for young girls who show promise in the science fields and convince them that a career in those fields is within their grasp. Britain has a woman at the head of its monarchy and leading its government. Where are all the women engineers?

MARY-ANN HUBERS . . .

NEXT MONTH . . .

THE NUCLEAR ISSUE—Informative comment plus a Geiger Counter constructional project

BETTER USE OF BATTERIES—The failure mechanisms and secrets of sealed nickel cadmium cells

CAD IN ELECTRONICS—Computer aided design, manufacture and testing is now available to the hobbyist. In the first of a series of articles, PE looks at its use in Industry

COMPUTER AIDED CHIP TESTER—Automatic test equipment project for CMOS and TTL logic devices

FIBRE OPTIC DATA LINK—Designed for serial digital communication using the RS232 standard

INDUSTRY NOTEBOOK

BY NEXUS

Expectations of expert systems and fewer feather beds

WHETHER artificial intelligence (AI) can be considered a part of electronics or vice versa is a matter for academic debate. Certainly they are interdependent. What is more important from the industrial point of view is whether AI can give the computer manufacturing sector a much needed pick-me-up.

In the USA the electronics industry is heavily weighted towards computer manufacturing and the trading in this sector has been very depressed during 1985/86. Honeywell, for example, recently reported a 40% drop in after-tax profits and National Cash Register a corresponding fall of 26%. Even the giant IBM admitted to a downward slide of 7%. In the UK we have seen Sinclair Research in severe financial difficulties, with Sir Clive himself taking a big pay cut and virtually working for his bankers, and various other firms like Systime and ACT experiencing all kinds of troubles affecting their revenues.

THE BIG LEAGUE

If you like statistics you may be interested in how big some of the major electronics/electrical companies have become. Britain's largest manufacturing company, GEC, now has annual sales of about £5.5 billion and employs over 160,000 people. But the multinational giant Philips tops this with sales of £14 billion per annum, while West Germany's Siemens generates as much as £16 billion p.a. and employs 350,000 people (240,000 within Germany). Hewlett-Packard, which is purely electronic and specialises in instruments and computers, has sales revenues of £4.7 billion and employs 84,000 people.

All these big established companies have a policy of ploughing back a certain proportion of their sales income into R&D—very necessary in the fast moving technology of electronics. Philips, for example, allocates 7% of its revenues, which comes to the colossal R&D expenditure of nearly £1 billion per year.

But whether AI can actually do anything for computer manufacturing is somewhat unclear at the moment. First of all we don't really know what it is, except in very academic terms. It has been described as a body of technique by which the power of the computer may be harnessed to simulate human thought. Of course, existing computer applications are already simulating the purely logical and calculating processes of human thought. But AI is concerned with other, less mechanistic mental processes, such as inference, that can be used for solving problems. I suppose the boldest, riskiest form of inference is that intuitive process we call a hunch.

EXPERT SYSTEM

At present the form of AI which has really got off the ground is the expert system. The essence of this is that the computer stores empirical knowledge provided by the practical experience of many human experts in a given field. It can then be interrogated to answer questions, solve problems or draw conclusions, using a set of rules provided in the software. For example, in a medical diagnosis expert system, if the doctor writes in a group of symptoms which are not at all common or familiar to him, the expert system will list the probabilities with which this particular group is associated with different known illnesses.

Two other fields where uncertainties reign and all professional decisions are to some extent gambles are insurance and marketing. Both, I see, are now the subject of 'Alvey clubs' in the UK. These clubs are groups of people with common interests who get together under the aegis of the national Alvey programme for advanced information technology. It has a special section for intelligent knowledge-based systems (IKBS).

The latest club is the Econometric Model Building Expert System Club, or EMEX for short. Here the idea is to combine the knowledge of commercial experts to form econometric models of various markets, which can be interro-

gated when difficult commercial decisions have to be taken. The Henley Centre for Forecasting provides the econometric expertise needed, while an AI firm called Expert Systems International Ltd contributes particular skills in 'knowledge engineering' and the design of expert systems.

As for the electronic hardware needed for AI, this seems a pretty open question at present. But listen to Prof. Edward Feigenbaum, a director of Sperry. At a recent conference he said: "Knowledge engineering is software critical. Some tasks can be run on a microcomputer while others are too slow on a Cray." However, he was able to envisage an ideal machine which had 'embedded code, high speed chip processors and lots of memory'. Not surprisingly, he cited a Sperry product, the Explorer, as one example of such a system. Others were Texas Instruments and Sun microcomputers. But some authorities on AI think a fundamentally new type of hardware will be needed to get optimum results—perhaps with many Transputer-like processors working in parallel with continuous communication.

"Knowledge engineering is software critical"

Already forecasts are being made of the sales revenues that might be expected from AI products. People in the USA are predicting revenues of £3-7 billion by the year 1990, rising to a staggering £700 billion by the end of the century. This implies a lot of money going into AI research in the meantime. As an example, Britain's STC has just signed a £6.5 million contract for research into building knowledge-based systems. This comes under the EEC's Esprit programme for Europe and includes as partners the companies Scicon, Scientific Control Systems and Cap Gemini Sogeti (a French software house). The Esprit projects, as you may have gathered, are run jointly by academia and industry. Here the academic partners are the University of Amsterdam and the Polytechnic of the South Bank in London.

DEFENCE SPENDING

Much as I applaud most of the activities of the UK electronics industry, I'm glad to hear that in future I won't have to contribute quite so much towards its upkeep out of my own pocket. I refer, of course, to the money we all have to pay through income tax, to fund the Ministry of Defence's spending on military equipment. This spending is now running at about £8.5 billion a year.

The Government has decided to cut the notorious 'cost-plus' system by which it pays its electronics and other contractors. Under this scheme it has been giving the contractors interim payments of up to 100 per cent of costs as the work proceeds. And often these payments continue even when the contract falls several years behind schedule—as with the Nimrod early warning radar project I discussed in the March issue.

Then the Ministry pays the contractor his profit on top. But the firm doesn't always have to wait till the job is finished before it gets that. The MoD has been in the practice of making interim payments of profit as well. George Younger, the man who succeeded Michael Heseltine as defence minister after the Westland affair, has

described the whole system as 'generous'. Many people who earn their living under somewhat harsher commercial conditions will consider this a polite euphemism for feather-bedding.

When you think how strongly the present government is wedded to the idea of the completely free market, in which all trading is ruled by the prevailing market forces, it's surprising that the 'cost-plus' system has been allowed to continue for so long. At least, it shows that all those ex-ministers and military men on the boards of the leading companies have been doing a good lobbying job for their employers.

PCB INVENTORS

The printed circuit has become such an established and familiar method of electronic construction that one tends to forget it was actually thought up as a new idea by someone at some time. I'm therefore glad to see that one of the pioneers of the p.c.—if not "the" inventor of the technique—has been given a well-deserved accolade for his work in this field. Dr Paul Eisler has received the Institute of Circuit Technology Award in recognition of his achievements over some 25 years. During this time he has filed over 50 patents.

Meanwhile the industry continues to profit from the original invention. Where would computer and telecoms manufacturers be today without the p.c.b.? Frost & Sullivan, the market forecasters, reckon that in Western Europe alone the sales of p.c.b.s will rise from a 1984 figure of £900 million to £1.75 billion by 1990. They predict that sales of multi-layer circuits will continue to grow rapidly, at the expense of single- and double-sided boards. The flexible type of boards are likely to remain with their present 5% of the market.

Long before the present style of p.c. started to replace wired connections in electronics, a British inventor of Hungarian origin, John Sargrove, built an automatic machine for making simple radio sets without conventional wiring. It was called ECME (Electronic Circuit Making Equipment) and was intended to churn out huge quantities of cheap radios for the Kuomintang regime of Chiang Kai-shek in China. These were to be distributed to the Chinese people to facilitate Chiang's political propaganda through broadcasting. But when the Kuomintang regime was militarily defeated by Mao Tse-tung's communists, no more money was forthcoming from China and the ECME project had to fold. **PE**

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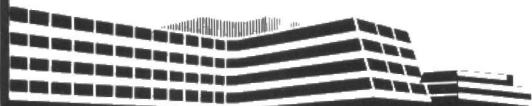
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NEWS LATEST . . .

Xicor have announced a new device the E2POT, an eight pin digitally controlled potentiometer. The chip allows the digital control of an on chip ladder network of resistors which form a 99 step potentiometer. Three pins control the 'wiper' position and the last position of the wiper is automatically stored in a non volatile register. This allows the device to be set and to retain this setting until changed. The chips are available in three decades of resistance range, starting at 10K.

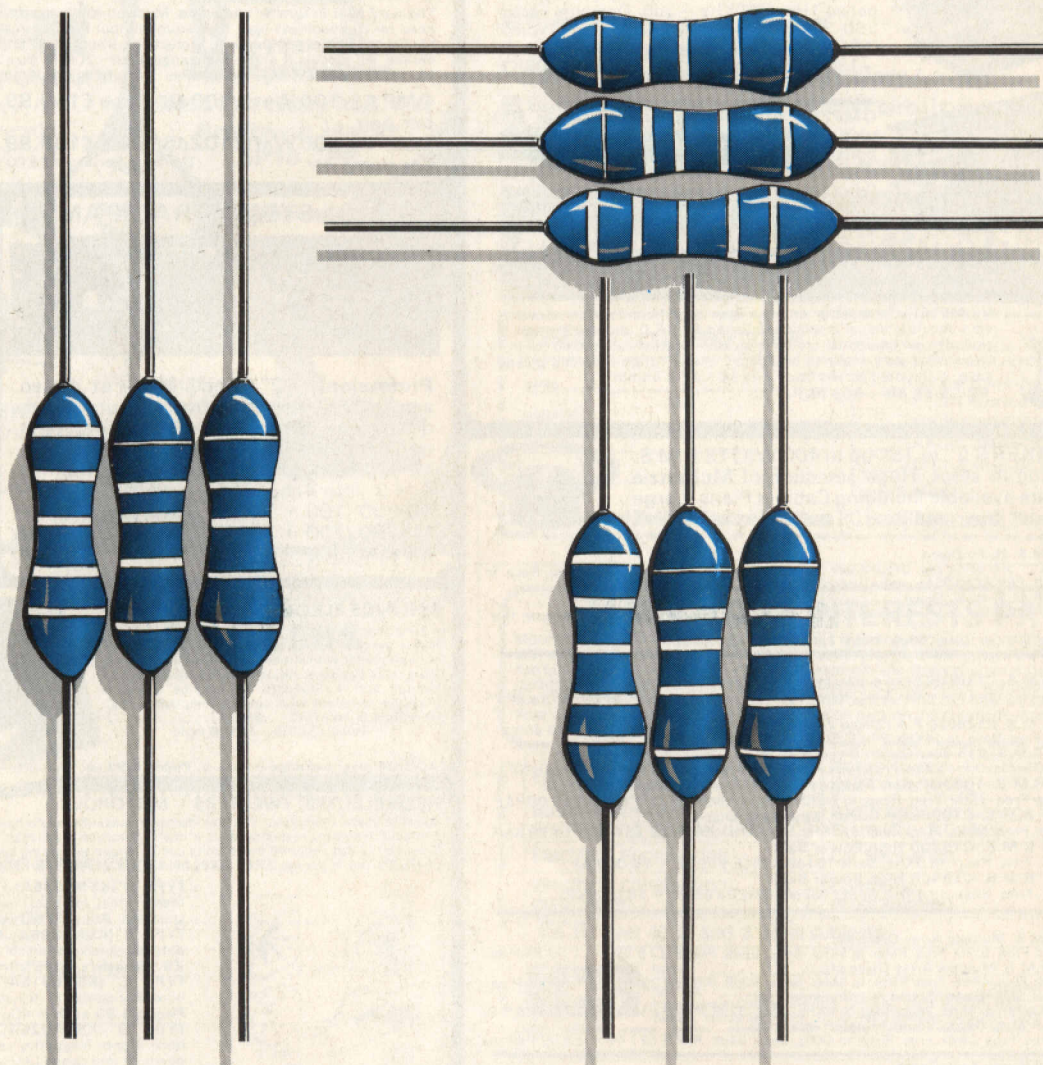
Fujitsu have just launched a range of 1Mbit CMOS EPROMS. They are available in four versions and all have access times of between 150ns and 250ns coupled with low power consumption. Probably the most useful of the versions is the MBM27C1000 which is organised as 128K x 8bits in a 32pin package.

One way of overcoming the problem of easy communications between a computer and a human user is to use a touch screen. This technology has been available for some time and is a standard on one of the Hewlett Packard personal computers where it compliments the keyboard and other input devices like tablets and mice. The standard way of creating a touch screen has been to use a matrix of infra-red beams and detectors just in front of the screen, these are scanned like a keyboard to see if any are broken by a finger touching the screen. However, R.H.Technical Industries Ltd have produced a new low cost alternative. This uses a transparent membrane touch switch which can be placed in front of the screen. This device should open up opportunities for software companies to produce low cost user friendly interactive software for a wide range of personal computers.

'Smart cards' which incorporate an electronic circuit have been much in the news recently as a replacement for the ordinary plastic credit card with its magnetic stripe. The 'smart card' is intended to be one of the central components of the so called 'cashless society'. The card incorporates a microprocessor and associated memory and is virtually tamper proof and unforgeable. Fujitsu have just launched a range of 'smart cards' and memory cards. The Fujitsu 'smart cards' incorporate an 8 bit microprocessor with either 64K or 256K of EPROM memory imbedded into a thin plastic card the size of a normal credit card. Secure data areas can be created in different parts of memory thereby ensuring proof against forgery or illegal data transaction. The 'memory cards' are designed to store data in an easily transportable form, they can hold up to 8M of CMOS memory which is again embedded into a credit card size sheet of plastic. Both card types have electrical connections along one edge of the card and receive electrical power from the reading device.

Mullard have launched what is believed to be a 'world first' in flat CRT TV tube technology. The screen is 19cms diagonal but only 5cms deep and has been dubbed by Mullard 'Slimscreen'. It is a high technology folded optics cathode ray tube which gives a flat TV display with a conventional 4:3 aspect ratio. The tube offers high resolution plus good screen brightness and contrast. Currently these tubes are only available in a monochrome version but colour versions are being developed and should be announced in the near future.

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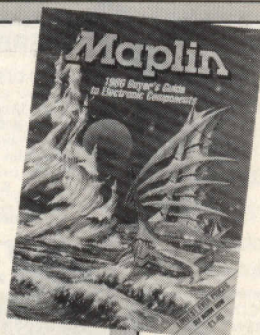
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